FUSION

Close Down Report

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1. Introduction

This is the Close Down Report (CDR) for Project FUSION, the aim of which is to share the key learnings generated by the project.

SP Energy Networks submitted the proposal for Project FUSION in 2017 under the Network Innovation Competition (NIC) funding mechanism. Ofgem approved the proposal and issued the Project Direction on the 28th of September 2018. Live trials commenced in September 2021, inaugurating GB's first ever Universal Smart Energy Framework (USEF)-compliant flexibility market, before concluding as planned in April 2023.

The publication of this Close Down Report (CDR) marks the successful completion of the project.

2. Executive Summary

2.1. Background & Scope

Project FUSION was funded under Ofgem's 2017 Network Innovation Competition (NIC), to be delivered by SP Energy Networks in partnership with the following project partners: DNV (formerly: DNV GL), Origami Energy (recently acquired by Baringa), Imperial College London (academic partner), SAC Consulting, Passiv Systems, The University of St. Andrews, and Fife Council.

Project FUSION represented a key element of SP Energy Network's transition to becoming a Distribution System Operator (DSO), taking a step towards a clean, smart and efficient energy system. As the electricity system changes from a centralised to decentralised model, project FUSION and its learnings could enable the functioning of a smarter and more flexible network.

The project's scope was to trial the use of commoditised local demand-side flexibility through a structured and competitive market, based on a market-based framework; the Universal Smart Energy Framework (USEF). USEF provides a standardised framework that defines products, market roles, processes and agreements, as well as specifying data exchange, interfaces and control features.

The trial area in scope for the deployment of Project FUSION was East Fife, specifically defined as the network area supplied by the primary substations at St Andrews and Leuchars. This area was selected because both load growth projections at the time that the project started and the integration of distributed generation were leading to localised network constraints (thermal) which FUSION could alleviate[1].

2.2. Outcomes

Project FUSION successfully established and operated the first fully USEF-compliant flexibility market in Great Britain. Two aggregators participated in the trial: GridImp and Orange Power with a wide range of flexible technologies. The trial was live for two years and the aggregators represented a total of 1.7MW of nominal Distributed Energy Resource (DER) capacity connected to the congestion points. FUSION tested three of the Energy Network Association's (ENA) standardised products that use flexibility to respond to pre- and post-fault events:

- *Sustain* and *Secure* are both pre-fault products that are either scheduled well in advance or dispatched closer to real-time respectively.
- *Dynamic* is a post fault product where flexibility is dispatched following a network event.

During the 18-month trial, the DNO issued approximately 700 requests for flexibility, with 94% receiving at least one offer from aggregators. This resulted in aggregators delivering nearly 50MWh of flexibility over the trial period, which accounted for roughly 80% of the DSO's ordered flexibility.

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1 By 2019 the local network (particularly the St. Andrews Primary substation) was experiencing significant load excursions. The Long Term Development Statement (2019-2029) indicated further localised load growth. A new primary substation would take 7-9 years to plan and build and, in the interim, new connections could no longer be accommodated.

The trials of the project's methods have resulted in several useful outputs for project stakeholders and for potential application of USEF-based mechanisms, including: Flexibility Services Agreement Template, FUSION USEF Implementation Plan, Communication protocols between market participants, Specification of communication and procurement platform, the Interim Trial Learnings Reports (#1, #2, #3 and #4) and the UFTP Specification Library.

2.3. Updated Business Case

An updated business case of the project was developed based on the trial results, project's observations and developments in flexibility markets. This business case is premised upon USEF encouraging wider participation in flexibility markets from residential customers. Although there is not sufficient evidence to definitively establish a causal relationship between USEF factors and high residential participation, certain features of USEF could contribute it, based on FUSION's observations and feedback from stakeholders.

Assuming there is a causal link between USEF and residential participation, implementing a FUSION-style flexibility market has a net present value of system benefits ranging from £2.9 billion to £5.8 billion in 2050 across various scenarios compared to a counterfactual scenario where in which the FUSION concept is not implemented. From a whole-system perspective, the overall net present value is positive. When considering the local benefits of the trial in East Fife, the magnitude of USEF-based flexibility benefits is rather modest as the total cost of USEF Implementation and flexibility payments of about £2m significantly outweigh the benefits (£5k against £2million), leading to negative benefits.

2.4. Objectives & Project Direction Deliverables

The project's core objectives are presented in the table below together with key outcomes.

1. Cost Benefit Analysis (CBA) [2] Meeting the Objective: As might be expected for an innovation project, the localised deployment exhibited a negative business case[3]. In contrast, the business case for GB roll out was positive, but that outcomes should be treated with caution as it relies upon certain assumptions of residential participation.
2. Investigate Commercial Mechanisms Meeting the objective: FUSION commercial mechanisms were reported influential in securing participation from multi-vector electrical applications, such as free bids (discretionary bids), automation, USEF standardised trading flow and day ahead trading.[4]
3. DSO Potential to accelerate new connections Meeting the Objective: High reliability (80%) provides DSO with confidence that flexibility services can be used to 1. manage network demand for pre-planned network events, and 2. reduce demand anxiety amongst network designers and operators. During the 2022 St Andrews' Open and associated unplanned outage Project FUSION provided standby capacity which was available to accommodate peak loads.[5]
4. Efficient DNO network management Meeting the Objective: Local flexibility can help to alleviate constraints on higher voltage parts of the network, and provide additive or complimentary flexibility support to the common network (i.e., two substations). **Error! Bookmark not defined.**

2 The Cost Benefit Analysis report which is the key output to meet this objective can be found in project FUSION website.
3 Local benefits:~ £5k. FUSION implementation and operation costs: £2m.
4Full assessment of this objective is included in ITLR#3, section 4.8
5 The detailed analysis of this objective can be found in the report 'FUSION ITLR4 – Report on Origami Actions'.

5. Proof of concept for a USEF-based flexibility market
Meeting the objective: Project FUSION successfully demonstrated the live operation of a USEF-based flexibility market in GB and contributed to improvements of USEF Framework and Flexibility Trading Protocol. [6]

All deliverables were completed successfully and submitted in line with the schedule agreed with Ofgem. Links to the deliverables can be found in Section 1.1 of this report.

2.5. Main Learnings Derived from the Method(s)

Learnings are split into 2 sections: Main Learnings Derived from the Methods and Main Learnings generated by the project. The first section refers to learnings directly linked to USEF, which is the method tested, and they are learnings from the USEF Innovative Elements. The latter reflects generic learnings from the project which are relevant to flexibility markets.

The main learnings derived from applying the USEF framework (the Method for project FUSION) are derived by trialling the USEF Innovative Elements (UIE) and are summarised below and are analysed in section 4.1 of this report.

Finding 1 - (UIE: Market Coordination Mechanism)[7]	A standardised process for how market participants engage with the market provides benefits to all involved stakeholders. In addition, features such as day ahead trading can increase reliability of flexibility.
Finding 2- (UIE: USEF Flexibility Trading Protocol).	Automation of flexibility trading processes make the trading as frictionless as possible. Automated processes enable aggregators to manage large portfolios of small assets, which otherwise would be more time consuming and costly.[8]
Finding 3 - (UIE: Common Reference (CR))[9]	A standardised dataset that maps congestion points against connections, assets, and aggregators provides increased market transparency and DSO visibility on active aggregators. The automation and smooth process of onboarding new assets is critical for aggregators.
Finding 4 - (UIE: nomination baselines)[10]	Baselining accuracy is a constant challenge for aggregators, including nomination, historical and MBMA baseline methodologies. Baseline inaccuracy leads to a bandwidth for service delivery and is one of the factors that increase DSO procurement costs or endanger the effectiveness (reliability) of congestion management.
Finding 5 - (UIE: D-programmes)[11]	Greater visibility of Low Carbon Technologies (LCTs) demand and generation behind the meter could potentially contribute towards improving forecasts for flexibility in LV networks, where the DSO has very limited visibility.
Finding 6 - (UIE: free bids)[12]	The flexibility bidding of non-firm assets outside contractual windows (discretionary bids) could encourage non-firm asset participation, and improve reliability of flexibility. However, the current market and payment structures are not mature enough yet to fully leverage this mechanism.

6 Full assessment of this objective is included in ITLR#4, section 4.1.6.
7 ITLR#4, section 4.1.3.
8 ITLR #4, section 4.1.5
9 ITLR#3, section 4.1
10 ITLR#3, section 4.4 and ITLR#4, section 4.1.2.
11 ITLR#2, section 4.3
12 ITLR#3, section 4.3 and ITLR#4, section 4.1.1

Finding 7 - UIE: sub-metering [13]	Sub-metering improves forecasting of asset behaviour, offers better data resolution and enhances informed control of assets compared to boundary metering.

2.6. Main Learnings Generated by the Project

2.6.1. Learnings for DSOs and Aggregators

The main learnings for DSOs and aggregators are presented below and are analysed in sections 4.3 of this report.

Learnings for DSOs	Learnings for Aggregators
Learning 1: Flexibility providers value an end-to-end process with automation in areas such as settlement, information exchange and dispatch instructions. They also value integration of all processes in one platform. [14]	**Learning 1:** Aggregators should have the capability to process large amounts of data in order to effectively and efficiently participate in flexibility services.
Learning 2: The effectiveness of non-firm assets bidding outside contractual windows or above contracted capacity is dependent on the contractual arrangements and payment structure. [15]	
Learning 3: Shorter procurement timeframes[16] allow the DSO to order flexibility based on a more accurate forecast and increases reliability of flexibility. This must be balanced with need to give flexibility providers visibility over when flexibility might be required.[17]	**Learning 2:** Aggregators over-delivered flexibility volumes during the FUSION trial mostly due to baselining inaccuracies but also driven by contractual arrangements related to penalties when contracted flexibility was not delivered.
Learning 4: The DSO needs to over-procure[18] flexibility to account for their own load forecast inaccuracy, aggregator baseline inaccuracy and reliability of delivery (which project FUSION has defined as DSO procurement cost drivers). Baseline accuracy has the largest impact on the additional volume of flexibility required by the DSO.[19]	
Learning 5: Some USEF and FUSION commercial mechanisms, such as day ahead trading, discretionary bids (i.e. free bids) were reported by aggregators as having been influential in securing customers participation, particularly from residential flexibility providers. [20]	**Learning 3**: Aggregators must continually monitor the accuracy of their baseline and, where possible, update their methodology if required to ensure accuracy.
Learning 6: DSO's should collaborate closely with aggregators on baselining for better, fairer and more efficient flexibility markets	**Learning 4**: DSOs will only consider relying on 'free bids' if there is sufficient market liquidity and mature markets.[21]

13 ITLR#2, section 4.5.
14 Linked to USEF UIE MCM findings. ITLR#4, section 4.1.3
15 Linked to UIE free bids. ILTR#4, section 4.1.1.
16 Day-ahead and intraday versus BAU week-ahead timeframe
17 Linked to UIE MCM, ITLR#4, section 4.1.3
18 The analysis in Section 4.2 suggests that, during the FUSION trials, flexibility was over procured by up to a factor of 4. Section 4.7 provides further detail.
19 ITLR#3, section 4.7
20 Section 4.2 in ITLR#2 and section 4.2.3 in ITLR#4.
21 Linked to UIE free bids. ITLR#4, section 4.1.1.

Learning 7: Learnings and opportunities from international experience and collabor The analysis in Section 4.2 suggests that, during the FUSION trials, flexibility was over procured by up to a factor of 4. Section 4.7 provides further detail.ation can enable more efficient operation of flexibility markets and encourages participation	**Learning 5**: Aggregators faced challenges in recruiting new flexible assets, driven by technical limitations but also market arrangements. [22]

2.6.2. Shortlisted recommendations

Consolidating all the learnings from the trial, the USEF innovative elements and their impact on DSOs and Aggregators, project FUSION has shortlisted the following recommendations for the GB industry with regard to DSO flexibility markets.

Standardisation in flexibility markets 	The comprehensive scope of USEF's Market Co-ordination Mechanism (MCM) could help to inform the UK's journey toward a highly automated flexibility trading standard.[23]
Automation in flexibility markets 	DSOs to consider adopting the automation that USEF delivered for transactive flexibility trading, the automation for settlement processes, and the development of a single end-to-end platform with high degree of automation.[24]
Aggregator Baselining [25] 	DSOs to consider incorporating on-going monitoring of the baseline accuracy in a standardised way across DSOs to: • Provide feedback to aggregators and investigate where improvements can be made • Understand the baseline impact on flexibility delivery and network impact
Commercial Mechanisms & User experience [26] 	DSO's & aggregators to consider the potential benefits of the following USEF features and FUSION mechanisms: • Targeted recruitment campaign for residential customers • Automation in trading processes and communication • Discretionary bids & day-ahead trading • Smooth onboarding process of new assets via the Common Reference
DSO Cost Procurement Drivers[27] 	DSOs to consider how best to split the risks of flexibility reliability (and baselining implications) between DSO and aggregators to ensure network reliability whilst avoiding unnecessary entry barriers for aggregators. Understand how different measures to split this risk would impact each stakeholder.

22 More details can be found in section 5.3 of this Close Down Report
23 See section 4.1.1 of this report
24 See section 4.2 - Learning 1 of this report
25 See section 4.3 of this report, Learning 3
26See section 5.2, objective 2
27 See section 4.3 of this report, Learning 4

3. Details of Work Carried Out

3.1. FUSION Background and Structure

Project FUSION was funded under Ofgem's 2017 Network Innovation Competition (NIC), to be delivered by SP Energy Networks in partnership with the following project partners: DNV (formerly: DNV GL), Origami Energy (recently acquired by Baringa), Imperial College London (academic partner), SAC Consulting, The University of St. Andrews, and Fife Council.

Project FUSION represents a key element of SP Energy Network's transition to becoming a Distribution System Operator, taking a step towards a clean, smart and efficient energy system. As the electricity system changes from a centralised to decentralised model, project FUSION and its learnings could enable the functioning of a smarter and more flexible network. Project FUSION trialled the use of commoditised local demand-side flexibility through a structured and competitive market, based on a universal, standardised market-based framework; the Universal Smart Energy Framework (USEF). USEF defines products, market roles, processes and agreements, as well as specifying data exchange, interfaces and control features. The purpose of USEF is to accelerate the transition to a smart, flexible energy system to maximise benefits for current and future customers. A detailed introduction to USEF is presented in Section 3.2.1.

3.2. Innovation Trialled and Learning Objectives

3.2.1. Universal Smart Energy Framework (USEF)

Project FUSION trialled the use of commoditised local demand-side flexibility through a structured and competitive market, based on a universal, standardised market-based framework; the Universal Smart Energy Framework (USEF). When project FUSION innovation idea was submitted to Ofgem, USEF unique features provided a compelling and innovative framework to be trialled in FUSION and meet its objectives:

- USEF enables a market – based approach to unlock the value of flexibility
- USEF has a comprehensive scope of flexibility trading (from contract to settlement). This is achieved via the Market Coordination Mechanism (MCM) which is discussed later in the section (Figure 2 and section 4.1.1)
- USEF provides a framework for automate flexibility trading processes
- USEF supports standardisation, including international standardisation, of flexibility services.

Prior to FUSION, USEF was already implemented and trialled in other project in European Union (EU) and mostly in the Netherlands, which means that the selected method had a satisfactory Technology Readiness Level (TLR), as per NIC requirements.

The USEF framework aims to facilitate effective coordination across all the different actors involved in the electricity market by providing a common standardised roles model and market design while describing communication requirements and interactions between market roles (Figure 1). USEF turns flexible energy use into a tradeable commodity available for all energy market participants, separated from (but in coordination with) the traditional electricity supply

chain, to optimise the use of resources. USEF focuses on explicit[28] demand-side flexibility, in which active consumers (also known as 'prosumers') are contracted by the aggregator to provide specific flexibility services using Active Demand and Supply (ADS) assets. USEF acknowledges but does not provide detailed considerations for implicit[29] demand-side flexibility or peer-to-peer energy trading.

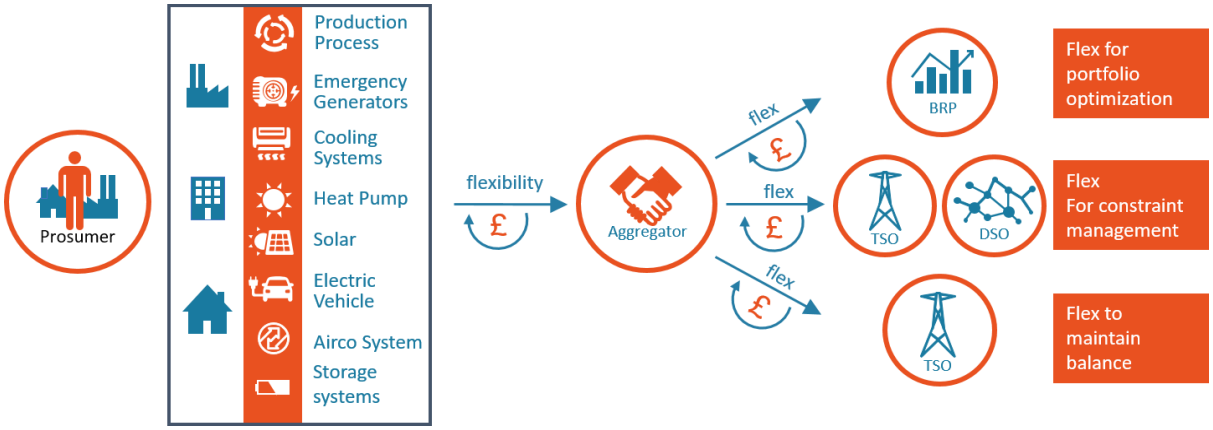

Figure 1 USEF model of interoperable roles, centred around the Aggregator role

To facilitate the transition towards a cost-effective and scalable model, the framework provides the essential tools and mechanisms which redefine existing energy market roles, add new roles and specify interactions and communications between them. In addition, USEF's open IT architecture provides the freedom to create unique and commercially competitive smart energy products and services without vendor lock-in and delivers a common standard on which to build, ensuring that technologies and projects are be compatible and connectable to the future smart energy system. By delivering a common standard, USEF connects people, technologies, projects and energy markets in a cost-effective manner. Its market-based mechanism (USEF Market Coordination Mechanism – MCM) provides a standard and comprehensive approach to flexibility trading and consists of five phases – contract, plan, validate, operate and settle (Figure 2).

Figure 2 USEF Market Co-ordination Mechanism

There are valuable innovative elements within USEF that enrich discussions and views on future energy market design, both broadening and deepening these views. Subsection 3.2.3 in this

28 Explicit Demand-Side Flexibility is committed, dispatchable flexibility that is exposed to energy markets and system operation products and can be traded on the different energy markets (wholesale, balancing, system support and reserves markets). Flexibility Customers may receive (financial) rewards for agreeing to respond to DSO or ESO requests to adjust their load or generation profile. This is usually facilitated and managed by an aggregator that can be an independent service provider or a supplier. This form of Demand-Side Flexibility is often referred to as "incentive driven" Demand-Side Flexibility. (Source: SEDC-Position-paper-Explicit-and-Implicit-DR-September-2016.pdf (smarten.eu)) https://www.usef.energy/app/uploads/2021/05/USEF-The-Framework-Explained-update-2021.pdf

29 Implicit Demand-Side Flexibility is flexibility which is provided by consumers as a reaction to price signal (e.g. variable electricity and/or grid tariffs).. Where consumers have the possibility to choose hourly or shorter-term market pricing, reflecting variability on the market and the network, they can adapt their behaviour (through automation or personal choices) to save on energy expenses. This type of Demand-Side Flexibility is often referred to as "price-based" Demand-Side Flexibility. (Source: SEDC-Position-paper-Explicit-and-Implicit-DR-September-2016.pdf (smarten.eu))

report defines the USEF innovative elements (UIE) and specifies learning objectives for each. Then, Section 4.1 details the findings and conclusions for each UIE.

USEF was initially developed by the USEF Foundation. In 2014, the USEF Foundation was founded to accelerate the establishment of an integrated smart energy market which benefited all stakeholders, from energy companies to consumers. USEF was an early mover, a combined force of parties and professionals with a shared goal. Together they explored new territories to help unlock and structure the future market and, as a result, many elements of USEF can now be found in standardisation and harmonisation policies at both national and European level.

By 2021, 7 years later, the stated objective of the USEF Foundation had been completed and therefore a decision was made to dissolve the USEF Foundation on 1 July. To safeguard[30] the legacy of the USEF foundation, the USEF framework, including the UFTP protocol (recently rebranded to Shapeshifter) has since been maintained by the GOPACS[31] organisation. The Shapeshifter protocol has also been adopted by the Linux Energy Foundation, offering a platform for the maintenance and support of the protocol.

3.2.2. Project FUSION Objectives

Project FUSION submission proposal (FSP) objectives

Project FUSION Submission Proposal (FSP) objectives are the overall FUSION project objectives, which were submitted to and approved by Ofgem. For each FSP objective, a number of learning objectives/questions were specified to explore throughout the project. These learnings objectives were agreed by project FUSION partners through a number of workshops in order to ensure that the learnings and outcomes would be valuable for GB industry but also achievable. The learnings objectives/questions which steered the analysis during trial implementation and ensured that the initial questions were answered. Table 1 describes the FSP objectives and their underlying learning objectives. The findings and conclusions for each of the objectives can be found in Chapter 5.

Table 1: FSP objectives and their underlying learning objectives.

FSP Objective	Description of FSP objective	Learning objectives/questions for each FSP objective
1. Cost benefit analysis (CBA)	Evaluate the feasibility, costs and benefits of implementing a common flexibility market framework based on the open USEF model to manage local distribution network constraints and support wider	1. Establish impact of USEF model on flexibility CBA drivers: change in available capacity of flexibility
		2. Establish impact of USEF model on flexibility CBA drivers: change in availability of flexibility including change in common mode failures
		3. Establish impact of USEF model on flexibility CBA drivers: shape of load recovery model,
		4. Establish impact of USEF model on flexibility CBA drivers: change in costs for DSO to acquire or activate flexibility

30 The USEF Framework and the UFTP continue to be available to everyone and fully applicable and operational. The Shapeshifter group continues the legacy USEF technical steering committee meetings, where the design team, stakeholders, aggregators etc, meet to discuss USEF (Shapeshifter) developments, new requests for improvements of the protocol etc.

31 GOPACS is the congestion management platform of the Dutch grid operators. Through GOPACS, [the grid operators] try to reduce congestion in the electricity grid, taking into account local network conditions as well as balancing at national level. (Source: About GOPACS - GOPACS)

	national network balancing requirements.	5. Establish impact of USEF model on flexibility CBA drivers: change in absorption of (additional) renewable energy resources)
2. Commercial Mechanisms	Investigate a range of commercial mechanisms to encourage flexibility from energy consumers' use of multi-vector electrical applications in satisfying overall energy use.	1. What are the commercial mechanisms available to aggregators to encourage participation?
		2. Which commercial proposition offered by the two aggregators in Year 1 of the FUSION Trial attracted the most participants?
		3. Do 'FlexOptions' contracts and Free Bids provide more incentives for flexibility utilisation by aggregators than business-as-usual (BAU) processes? Are there opportunities for these processes to be used more effectively?
3. DSO potential to accelerate new connections	Explore the potential for localised demand-side flexibility utilisation to accelerate new demand connections to the network that otherwise would require traditional reinforcement.	1. Can flexibility services be used to sufficiently control demand on the network and mitigate constraints? And, if so, how?
		2. Is the level of confidence in delivery of flexibility from demand groups suitable to satisfy DNO / network risk management requirements?
		3. Do flexibility service contracts hold suitable assurance on the provision of flexibility over the long term where network reinforcement would otherwise be required? And, if so, how?
		4. Are the levels of flexibility available sufficient to enable new connections without reinforcement?
4. Efficient Distribution Network Operator (DNO) network management	Gain an understanding of the potential use and value of flexibility within geographically local regions to further enhance efficient DNO network management.	1. Can local flexibility deliver the range of flexibility services which are available to regional (and national) markets?
		2. Can local flexibility provide suitable flexibility to all parts of the network (i.e., secondary primary, bulk supply point (BSP) (England), grid supply point (GSP) and Transmission System)?
		3. Can delivery of flexibility services at two local boundaries provide an additive or complementary flexibility support to the common network (i.e., two substations)?
		4. How will the value of flexibility alter in a low carbon world?
5. Business case for a USEF-based flexibility market	Demonstrate the proof of concept, and evidence the business case, of commoditised flexibility (locally and for GB) through a USEF-based flexibility market	1. Are there changes to USEF required for adoption by the GB energy market?
		2. Can the commoditization of all technologies be demonstrated? Does USEF create a level playing field?
		3. Are the network needs / service needs covered by the level of procured flexibility?

SP Energy Networks objectives

Alongside FSP objectives, SP Energy Networks has set up its own objectives to position them as the leading DSO on flexibility mechanisms and prepare the organisation for the transition from DNO to distribution system operator (DSO). Table 2 describes the SP Energy Networks objectives and their underlying learning objectives. The findings and conclusions for each of the objectives can be found in Chapter 5.

Table 2: SPEN objectives and their underlying learning objectives.

SPEN objective	Description of SPEN objective	Learning objectives from each SPEN objective
1. DSO Data Transparency	Explore to what extend FUSION can deliver DSO data transparency through the use of the Common Reference Operator (CRO).	1. To what extent can FUSION deliver transparency of the following data, and what could be done to enhance this? Network data (constraints etc.), market data (costs etc) and dispatch data (events duration etc).
		2. How to enhance interaction with market players – including privacy aspects?
		3. Would sufficient transparency lead to more or less flexibility being activated by the DSO?
		4. Would sufficient transparency lead to more or less flexibility being unlocked and offered by the aggregator (AGR)?
2. Coordination with the electricity system operator (ESO)	Demonstrate a coordinated approach with the ESO to managing potential conflicts between ESO and DSO services	5. Conduct a joint trial with the ESO to test the implementation of 'primacy rules' developed by the ENA

3.2.3. USEF Innovative Elements (UIE) – Learning objectives

In order to meet the project objectives, project FUSION tested and analysed a number of USEF Innovative Elements (UIEs). The UIEs are USEF features that are used across different phases of the MCM as shown in Figure 3 below. The MCM and the UFTP sits across all MCM phases.

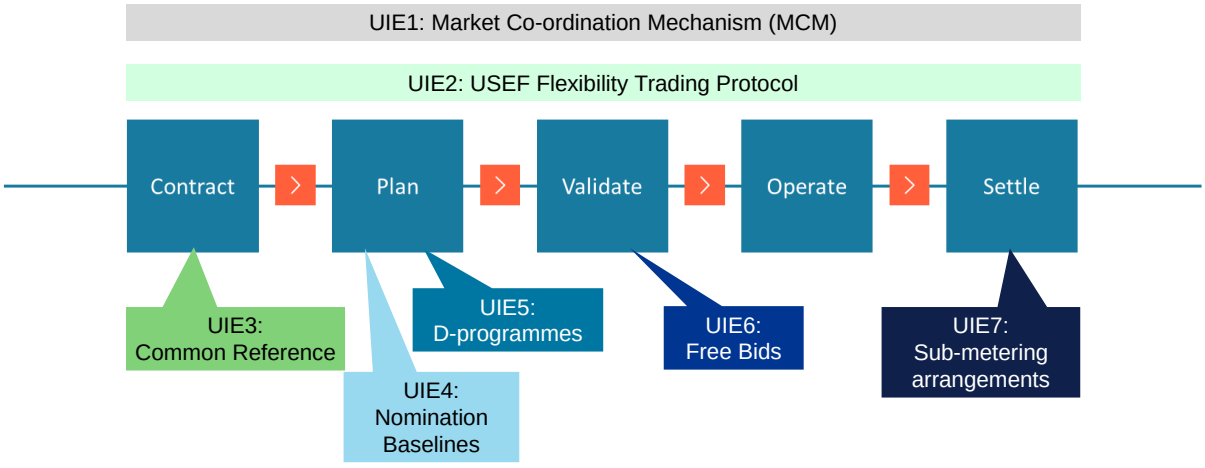

Figure 3 USEF Innovative Elements in MCM

The analysis of the UIEs provided evidence and information for answering project FUSION objectives and the learnings questions. Prior to the trial, the UIEs in scope for the trial were agreed by project FUSION partners. More specifically, project FUSION produced the USEF FUSION implementation plan, which described the planned deployment of innovative elements from the USEF framework in the flexibility market trial. Whilst developing the plan and based on stakeholders' feedback, which was obtained through the USEF consultation, project FUSION partners discussed and agreed which USEF processes and innovative USEF elements should be part of the trial, to offer more value and leanings to the industry (see section 3.3.3 for more details on USEF implementation plan and the steps that project FUSION completed).

The UIEs, their description and the learnings objectives that project FUSION met via the implementation of the UIEs in FUSION trial are summarised in

Table 3. Learnings form each UIE are described in Section 4.1.

Table 3. USEF Innovative Elements (UIE)

USEF Innovative Elements (UIE)	Description of UIE	Learning objectives from each UIE objective
UIE1: Market Coordination Mechanism (MCM)	USEF includes a market coordination mechanism (MCM) that describes the interaction between market parties related to (explicit) flexibility throughout different phases; the interaction between DSO and AGR is described by UFTP.	What is the experience of aggregators and DSO using the MCM?
		What is the FlexReservationUpdate value to the AGR (by bringing flexibility to other markets)?
		What is the value of Partial FlexOrders?
		What rebound considerations are needed?
UIE2: USEF Flexibility Trading Protocol (UFTP)	Interaction between the DSO and Aggregator has been formalised through the USEF Flexibility Trading Protocol (UFTP).	What is the experience using UFTP?
		Advantages of UFTP
		Areas for improvement
		Feedback to improve the protocol
		Changes to the protocol
UIE3: Common Reference Operator (CRO)	The primary use of the common reference is to map congestion points against connections and assets. Explore the dedicated role (CRO) that has been introduced by USEF to operate the CR.	Who should perform the CRO role?
		Should there be one Common Reference (CR) for GB?
UIE4: Baseline design	DSO products for congestion management typically use historical baselines as a basis for the validation and settlement of the delivery. A recent Energy Networks Association (ENA) study suggests widening up the possibilities for FSPs, by allowing nomination baselines when the default baseline in not sufficiently accurate. Within FUSION, a test can be performed on the	Can a nomination baseline provide higher accuracy than historical? If so, under which conditions?
		Which processes are needed for this baselining methodology (information exchange, monitoring)?
		How complex is the implementation of these processes?

	performance of these baseline types.	Would this (additional) baseline increase the inclusivity of the congestion management products?
UIE5: D-programmes	Within USEF, D-programmes have two functions: (i) to inform the DSO ex-ante how flexibility will be deployed (ii) they are the basis for settlement. The second function is addressed under "baseline design". This objective focuses on the first function, where D-programmes can be integrated in grid operations.	Can D-programmes (inc. varying timing) improve the forecasting accuracy for grid components? Would this lead to less flexibility being activated? How much?
		How should these forecasts be integrated in the forecasting process, e.g., how should sub-metering be handled?
		Is the current mechanism sufficient, or should it be augmented with other information, e.g., contractual information that could be added to the CRO?
UIE6: Free Bids	In current DSO flexibility procurement/deployment, only firm capacity is contracted. This disqualifies certain technologies, which cannot provide this firmness, from participating. The DSO could benefit from the use of free bids, as a wider range of technology could lower utilisation costs. FSPs controlling these technologies could benefit, as they have access to additional markets.	Which assets can participate in day ahead/intraday (DA/ID) congestion management that cannot be considered firm capacity?
		What is the effect on the liquidity / activation prices / DSO costs?
		How could assets that have no firm commitment to DSO services, participate in ESO services? What would be the positive impact of this kind of value stacking to whole system optimisation and carbon reduction?
		How can the business case of FSPs operating these types of technologies improve, when they have access to this additional revenue stream? Can we expect that this will lead to more (residential) AGRs participating in DSO products?
UIE7: Submetering arrangements	The choice either to use Meter Point Administration Number (MPAN) meter data or sub-meter data for service delivery validation and settlement may have a major impact, both on provider side and on DSO side. Where traditionally the electricity market was centred around MPAN metering, arrangement gradually open up to allow sub-metering (e.g., balancing services). The role of sub-metering in DSO services is largely unexplored.	Should the main- or sub-meter be used for settlement from the AGR perspective?
		Should the main- or sub-meter be used for settlement from the DSO perspective?
		Which meter data validation is required, when meter data is provided by flexibility service provide (FSP)?
		Which improvement on baseline accuracy is feasible when applying sub-metering, for which technologies?
		As a consequence, which technologies can only participate when applying sub-metering? What are the barriers for using MPAN?

3.2.4. Methodology applied to meet project objectives

To meet the learning objectives, various methods were used to generate the results both qualitative and quantitative. Qualitative evaluation of the trial results included interviewing the participating aggregators and SP Energy Networks to capture their experiences. The quantitative analysis used data which was generated during the 2 years of live trial. The data included the following items, although the list is not exhaustive:

1. Meter data – from each aggregator at portfolio level at each congestion point and from the DSO at the substation.

congestion_point	aggregator_name	congestion_point_type	period	latest_meter_message	metering_status
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED
Leuchars primary	GridImp	PRIMARY	04/05/2022 00:00	a19f24bd-3c07-4bcf-a362-91ebbaecbdfc	RECEIVED_AND_ACCEPTED

Figure 4 Example of Spreadsheet with Meter Data Information

2. Validation Phase Information – including D-programmes, FlexRequests, FlexOffers and FlexOrders.

flexrequest_id	period	congestion_point	expiration_date_time	created_at	star	time	requested_flex_min_power
c1456738-cf28-4e65-915f-8dd1962e42e7	19/04/2022 00:00	Leuchars primary	20/04/2022 00:00	18/04/2022 11:24	29	14:00:00	-199996
c1456738-cf28-4e65-915f-8dd1962e42e7	19/04/2022 00:00	Leuchars primary	20/04/2022 00:00	18/04/2022 11:24	30	14:30:00	-199996
c1456738-cf28-4e65-915f-8dd1962e42e7	19/04/2022 00:00	Leuchars primary	20/04/2022 00:00	18/04/2022 11:24	29	14:00:00	-199996
c1456738-cf28-4e65-915f-8dd1962e42e7	19/04/2022 00:00	Leuchars primary	20/04/2022 00:00	18/04/2022 11:24	30	14:30:00	-199996
c1456738-cf28-4e65-915f-8dd1962e42e7	19/04/2022 00:00	Leuchars primary	20/04/2022 00:00	18/04/2022 11:24	29	14:00:00	-199996
c1456738-cf28-4e65-915f-8dd1962e42e7	19/04/2022 00:00	Leuchars primary	20/04/2022 00:00	18/04/2022 11:24	30	14:30:00	-199996
85525b33-38b8-4243-aa73-1b0fb59ee1e8	19/04/2022 00:00	St Andrew Primary	20/04/2022 00:00	18/04/2022 11:22	29	14:00:00	-250000
85525b33-38b8-4243-aa73-1b0fb59ee1e8	19/04/2022 00:00	St Andrew Primary	20/04/2022 00:00	18/04/2022 11:22	30	14:30:00	-71250
85525b33-38b8-4243-aa73-1b0fb59ee1e8	19/04/2022 00:00	St Andrew Primary	20/04/2022 00:00	18/04/2022 11:22	29	14:00:00	-250000
85525b33-38b8-4243-aa73-1b0fb59ee1e8	19/04/2022 00:00	St Andrew Primary	20/04/2022 00:00	18/04/2022 11:22	30	14:30:00	-71250
85525b33-38b8-4243-aa73-1b0fb59ee1e8	19/04/2022 00:00	St Andrew Primary	20/04/2022 00:00	18/04/2022 11:22	29	14:00:00	-250000
85525b33-38b8-4243-aa73-1b0fb59ee1e8	19/04/2022 00:00	St Andrew Primary	20/04/2022 00:00	18/04/2022 11:22	30	14:30:00	-71250
37bfefc9-8de2-4de1-b2cb-d7fa86c2947c	20/04/2022 00:00	Leuchars primary	21/04/2022 00:00	19/04/2022 11:47	26	12:30:00	-330000
37bfefc9-8de2-4de1-b2cb-d7fa86c2947c	20/04/2022 00:00	Leuchars primary	21/04/2022 00:00	19/04/2022 11:47	26	12:30:00	-330000
37bfefc9-8de2-4de1-b2cb-d7fa86c2947c	20/04/2022 00:00	Leuchars primary	21/04/2022 00:00	19/04/2022 11:47	26	12:30:00	-330000
40a9bedc-31df-43bd-88be-73cd4fb87200	20/04/2022 00:00	St Andrew Primary	21/04/2022 00:00	19/04/2022 11:46	26	12:30:00	-300000
40a9bedc-31df-43bd-88be-73cd4fb87200	20/04/2022 00:00	St Andrew Primary	21/04/2022 00:00	19/04/2022 11:46	26	12:30:00	-300000
40a9bedc-31df-43bd-88be-73cd4fb87200	20/04/2022 00:00	St Andrew Primary	21/04/2022 00:00	19/04/2022 11:46	26	12:30:00	-300000
05e33ae3-6f00-4dcc-86e0-529a068869d2	21/04/2022 00:00	Leuchars primary	22/04/2022 00:00	20/04/2022 12:12	36	17:30:00	-81000
05e33ae3-6f00-4dcc-86e0-529a068869d2	21/04/2022 00:00	Leuchars primary	22/04/2022 00:00	20/04/2022 12:12	37	18:00:00	-300000
05e33ae3-6f00-4dcc-86e0-529a068869d2	21/04/2022 00:00	Leuchars primary	22/04/2022 00:00	20/04/2022 12:12	36	17:30:00	-81000
05e33ae3-6f00-4dcc-86e0-529a068869d2	21/04/2022 00:00	Leuchars primary	22/04/2022 00:00	20/04/2022 12:12	37	18:00:00	-300000
05e33ae3-6f00-4dcc-86e0-529a068869d2	21/04/2022 00:00	Leuchars primary	22/04/2022 00:00	20/04/2022 12:12	36	17:30:00	-81000

Figure 5 Example from Spreadsheet Used for Validation Phase Information

3. Trial Simulation Schedule – a pre-determined list of the FlexRequests and FlexOrders to be placed. The trial simulation schedule includes the plan for activating the test cases examined in this trial. Detailed information on the testing processes can be found in Interim Trial Learnings Report #1 (ITLR#1) , Section 3.5.2.

Date (dd/mm/yyyy)	Simulation number	Use case	Test case	FlexRequest Start Time (hh:mm)	FlexRequest End Time (hh:mm)	Duration (hh:mm)	When to send FlexRequest
18/04/2022							
19/04/2022	122	Dynamic	2.1	13:30	14:30	01:00	DA before 14:00
20/04/2022	123	Dynamic	2.1	12:30	13:00	00:30	DA before 14:00
21/04/2022	124	Dynamic	2.3	16:30	17:00	00:30	DA before 14:00
22/04/2022	125	Dynamic	2.4	18:30	19:30	01:00	DA before 14:00
23/04/2022							
24/04/2022							
25/04/2022							
26/04/2022	126	Secure	1.1	11:30 – 13:30	before 13:30	0:30-1:00	DA before 14:00
27/04/2022	127	Secure	1.3	-	-	-	-
28/04/2022	128	Secure	1.1	11:30 – 13:30	before 13:30	0:30-1:00	DA before 14:00
29/04/2022	129	Secure	1.2	13:30-15:30	before 15:30	0:30-1:00	DA before 14:00
30/04/2022							
01/05/2022							
02/05/2022							
03/05/2022	130	Sustain	3.3	-	-	-	-
04/05/2022	131	Sustain	3.1	11:00-14:00	before 14:00	0:30-1:00	DA before 14:00
05/05/2022	132	Sustain	3.2	14:00-16:00	before 16:00	0:30-1:00	DA before 14:00

Figure 6 Example of Simulation Schedule

4. Settlement Information – showing payments due and paid for delivered flexibility for each event and each aggregator.

total_ordered_flex	total realized flex	total delivered flex	adjustment factor 1 (SD_over_SI)	adjustment factor 2 (Volume_Factor)	unit_price	Payment Due
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
-199996	0	0	0.000	0.0	0.49	0
-199996	0	0	0.000	0.0	0.49	0
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
-250000	-442420	-250000	1.000	1.0	0.49	61.25
-71250	-444300	-71250	1.000	1.0	0.49	17.45625
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
-330000	-107304	-107304	0.325	0.0	0.49	0
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
-300000	-482240	-300000	1.000	1.0	0.49	73.5
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
0	0	0	0.000	0.0	0	0
-81000	-307840	-81000	1.000	1.0	0.49	19.845

Figure 7 Example of Settlement Spreadsheet

The data was downloaded from the FUSION Flexibility Platform's (FFP) central database using a combination of Structured Query Language (SQL) scripts and power query. It was then cleansed to avoid duplicate database entries and post-processed to enable the analysis.

Meter data from aggregators is only available for those days that FlexRequests were issued. As such, the analysis focuses exclusively on those days. The meter data includes the half-hourly imported and exported energy, which is then converted into net average power for each time interval (i.e., Import Energy – Export Energy).

More detail on the methodologies applied to analyse the data for each objective is presented in the FUSION's Interim Trial Learnings Reports #1, #2, #3 and #4. (sections Trial Learnings per Objective).[32]

32 https://www.spenergynetworks.co.uk/pages/fusion.aspx#tablist1-tab4

3.3. Work Packages

The work carried out as part of FUSION can be divided into the following broad elements (see Figure 8):

- A thorough and detailed analysis of flexibility available in the East Fife area across a range of market participants (WP2);
- A focused due diligence and public consultation about the participation of DNOs in the evolving flexibility market through the application of USEF which led to an implementation plan for USEF within GB and within FUSION trial; (WP3);
- Implementation of processes for the DSO and aggregators to be ready for when the trial goes live (WP4)
- A demonstration of this market in East Fife (WP5), including the procurement of flexibility by SP Distribution on an open flexibility market.
- Across the project delivery stakeholder engagement (WP1) and knowledge dissemination (WP6) were performed across different activities.

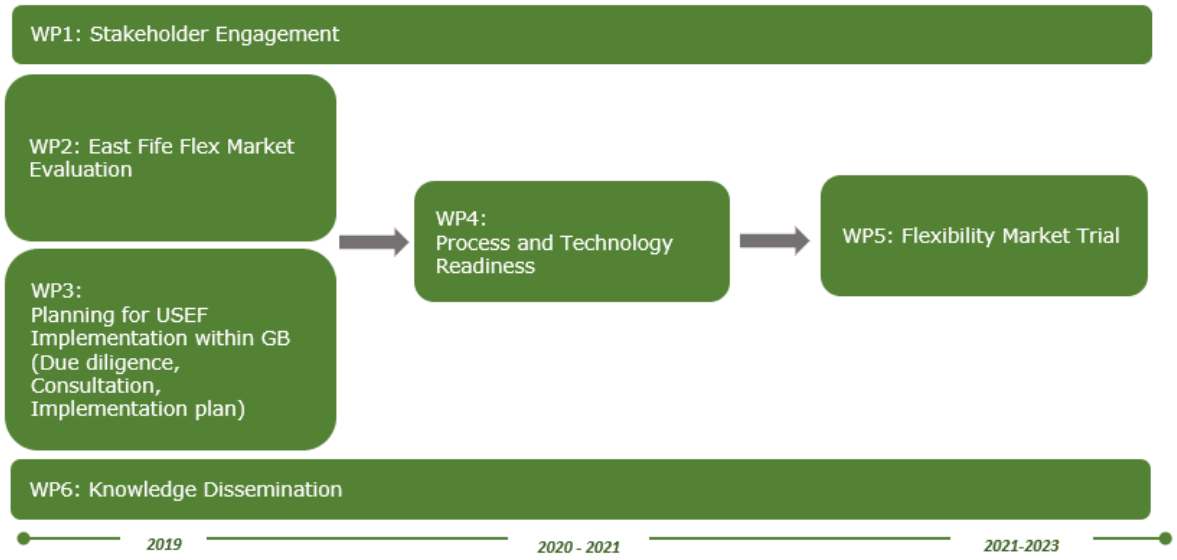

Figure 8: Project FUSION work packages

Work packages 2 and 3 were carried out in parallel during 2019 and 2020:

- The flexibility market evaluation (WP2) involved a comprehensive assessment of the available flexibility in East Fife, including customers connected at all voltage levels, to map the potential flexibility and determine the specific trial locations.
- The USEF Implementation Plan within GB stage (WP3) involved a due diligence of USEF against current and (likely) future GB energy market arrangements, a public consultation process[33] and culminated in the development of a reference implementation plan[34] for USEF in the GB energy market.

33 Full details of the Stakeholder Engement Process and its findings can be accessed through the Project FUSION website.

34 Full details of the USEF implementation plan can be accessed through the Project FUSION website.

These initial two stages informed WP4, Process and Technology Readiness, which was delivered during 2020. This stage implemented requisite processes and network flexibility planning tools that integrated with SP Energy Networks' existing network management tools to identify short-term and long-term flexibility requirements. This stage also included the implementation of USEF processes within the two aggregators which were contracted to participate in the trial. Moreover, Project FUSION commissioned the design, development and delivery of the FUSION Flexibility Platform (FFP) through which SP Energy Networks subsequently used to engage with participating aggregators in WP5.

The Flexibility Market Trial in WP5 involved an open tender for the procurement of flexibility contracts with aggregators and other providers of flexibility in East Fife. Operational interaction with aggregators was implemented using FUSION Flexibility Platform (FFP), which facilitated the procurement, dispatch and remuneration of demand response and local generation. Interim learning reports were prepared throughout the duration of the trial to provide ongoing feedback and recommendations for improvements[35]. At the end of the trial, the trial results were analysed, and learnings are made available to stakeholders through a range of appropriate dissemination methods (e.g., this Close Down Report and a close down in-person event).

The trial design (WP4) and implementation (WP5) are discussed in detail in Sections 3.3.4 & 3.3.5.

3.3.1. Work Package 1: Stakeholder Forum

Objective of the work package: The purpose of the stakeholder forum was threefold:

- connect and communicate with multiple groups across the industry and form and the basis of continual feedback and information exchange as the project progressed across local, national and international levels;
- review and map all relevant stakeholders, their interests and alignments with FUSION; and
- undertake national and trial location level stakeholder events.

Key activities

- Deeper-dive sessions at monthly Project Delivery Board (PDB) meetings with members of TEF (TRANSITION, EFFS, FUSION), the group of NIC projects supporting the DNO to DSO transition
- Regular engagement with ENA
- Quarterly progress meetings with Ofgem
- Fortnightly meetings with SP Energy Networks DSO team
- Participation in the Energy Innovation Summit in September 2022
- Monthly meetings with SHAPESHIFTER (formerly known as UFTP)
- Monthly FUSION partner meetings

35 All four interim learning reports (ITLRs) can be accessed through the Project FUSION website.

- Workshop with representatives from the TRANSITION project in the topic of baselining.[36]
- Industry webinars (flexibility tender exercise 1 and 2)
- Steering group meetings

Dependence with other work packages: This work package was dependent on outcomes of all other work packages to allow dissemination and engagement with industry. In addition, learnings from stakeholder engagement have informed the delivery of other work packages. For example, collaboration with TRANSITION has led to learnings on baselining. Monthly meetings with SHAPESHIFTER (ex- USEF Foundation) have informed implementation of UFTP.

Outcomes: Outcomes of this work package include regular steering of project direction, recording of meetings and facilitation of webinars and presentations.

3.3.2. Work Package 2: East Fife Flexibility Market Evaluation

Objective: The main objective of this work package was to map the potential flexibility and determine the specific trial locations. The objective involved comprehensive assessment of the available flexibility in the East Fife area based on connected customers across all voltage levels to determine specific trial locations. The assessment covered industrial, commercial, SME, farming and domestic sectors.

Key activities

- Desktop studies to determine a site's energy requirements and flexibility potential across multiple energy vectors (i.e., electricity, heat, and transport);
- Mapping of the full flexibility potential in the area to determine the specific trial locations;
- Customers, as potential flexibility providers, were invited to complete an Expression of Interest (EoI) and have their sites assessed to determine the potential flexibility that could be provided;
- Site-specific assessment of the flexibility potential;
- Invitation to trial participation, following the evaluation of the market potential and flexibility requirements.

Dependencies: This was the first work package that was completed. This package informed the recruiting processes of aggregators and flexible assets. Based on the outcomes of this work package, project FUSION partners engaged further with customers that could participate in the trial.

Outcomes: This work package concluded with the Report on flexibility quantification in East Fife. Refer to section 1.1 (ref.1) for project direction deliverables.

3.3.3. Work Package 3: Planning for USEF Implementation in GB

Objective: The objective of work package 3 was to develop a USEF implementation plan for the FUSION trials, and a blueprint for implementation of USEF across the energy sector in GB.

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36 Baselining workgroup (ssen-transition.com)

Key activities:

- Due diligence of USEF against the GB legal, regulatory and market frameworks, including current and future settlement arrangements. The main purpose of the due diligence was twofold:
    - To identify whether USEF is fit-for-use in the GB market;
    - To identify innovative elements in the USEF framework that could add value to the current thinking about future market design, and that can be trialled and proven within the FUSION project.
- The due diligence also examined:
    - the potential need for adaptions of USEF to make it compliant with relevant GB legal, regulatory and market arrangements;
    - the potential need for modifications to the current GB legal, regulatory and market arrangements to facilitate effective flexibility markets.
- The due diligence informed a public consultation on the merits and viability of implementing USEF innovative elements in GB and subsequently in FUSION trial. The consultation sought for stakeholders' feedback in order to inform the next stage of FUSION and which innovative elements should be trialled onwards.
- Consultation report: The outcomes of the consultation were summarised in the FUSION Consultation report which set out recommendations for implementing USEF in the GB energy system.[37]
- Development of GB USEF implementation Plan based on consultation outcomes
- Development of FUSION USEF implementation plan based on consultation outcomes and following discussion among project FUSION partners
- Identification of associated changes to USEF to be applied in the FUSION trial

Dependencies: This work package informed work package 4 activities which led to trial design and implementation (e.g., DSO FUSION Flexibility Platform Design, specification document, communication protocol and aggregators' implementation of UFTP) and it also informed the learnings objectives of the trial.

Outcomes: This work package concluded with the Due Diligence report,[38] the public consultation and the delivery of the FUSION USEF implementation plan and GB reference USEF Implementation plan. Refer to section 1.1 (ref.2 and 3) for Project Direction deliverables.

3.3.4. Work Package 4: Process & Technology Readiness

Objective: Implement the requisite processes and network flexibility planning tools that integrate with SP Energy Networks' existing network management tools to identify short-term and long-term flexibility requirements, including load forecasting, as well as develop the processes for establishing flexibility products linked to specific network constraints.

At the end of the work package – all tools and processes were in place for DSO and aggregators for the trial to go live.

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37 https://www.spenergynetworks.co.uk/userfiles/file/USEF_Consultation_Report.pdf?v=1.2
38 Project_Fusion_USEF_Due_Diligence_Report.pdf (spenergynetworks.co.uk)

Key activities:

- Design the specification of communication and procurement platform
- Design the communication protocols between market participants
- Procurement, development and implementation of the FUSION Flexibility Platform (FFP) as defined in Section 3.4.2
- Quantification of costs of USEF participation to market participants
- Procurement of flexibility services, including Flexibility Service Requirements (FSR), tender process, evaluation criteria and Flexibility service agreement.
- Support UFTP implementation by aggregators
- FFP and Aggregators platform testing and commissioning

More details on these activities and how project FUSION performed them are included in Section 3.3.

Dependence with other work packages: Results of the public consultation and the USEF implementation plan informed this work package. Outcomes and learnings from this package were a prerequisite to the commencement of the live trial in the next phase of project FUSION (WP5).

Outcomes: This work package concluded with the USEF process implementation in the FFP and aggregator interfaces[39], and the communication protocols between aggregators and the DSO[40]. Refer to section 1.1 (ref. 4) for Project Direction deliverables.

3.3.5. Work Package 5: Demonstration of USEF in East Fife

Objective: The objective of this work package was to conduct a live trial of a USEF-compliant flexibility market in East Fife, leveraging learning and outcomes from previous work packages, and to produce learnings for GB industry based on both qualitative and quantitative analysis.

Key activities:

- Procurement of DSO flexibility services as described in Section 3.4.2;
- Operation of the USEF-based flexibility market and trading flexibility services as described in Section 3.4.6 and 3.4.7;
- Regular reporting on USEF trial findings (see interim learning reports, ITLRs)[41];
- Cost benefit analysis, conducted by an independent team of Imperial College of London (ICL);
- Completion of the current Close Down Report;

Dependencies: The implementation and operation of the live trial was based on the learnings and outcomes from all the previous packages, particularly work packages 3 and 4.

Outcomes: The key outcome of this work package was to perform two live trials of a USEF-compliant flexibility market (Phase 1 and Phase 2) from September 2021 until April 2023. Learnings from the trials are capture in the Interim Trial Learnings Report (#1, #2, #3, #4). Refer to section 1.1 (ref 5 and 6) for Project Direction deliverables.

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39 https://www.spenergynetworks.co.uk/userfiles/file/D4.1_specification_of_communication_and_procurement_platform.pdf
40 https://www.spenergynetworks.co.uk/userfiles/file/D4.2_specification_of_communication_protocols_between_market_participants.pdf
41 All trial leanings report can be found at https://www.spenergynetworks.co.uk/pages/fusion.aspx#tablist1-tab4

3.3.6. Work Package 6: Knowledge dissemination

Objective: Maintain ongoing evaluation and reporting, and make learning available to all stakeholders through a range of appropriate dissemination methods

Key activities:

- TEF Deeper dive sessions (monthly);
- Presentation at conferences (e.g., ENIC 2020);
- Project Progress Reporting to Ofgem;
- Collaboration with the ENA's Open Networks Project on regular basis;
- Production of TEF summarised learnings (e.g., Product Catalogue and Service Definition);
- Publishing flexibility tenders;
- Holding show and tell sessions; and
- Analysis and publication of trial learnings

Dependencies: Knowledge dissemination was dependent on establishing learnings and findings across all previous work packages.

Outcomes: The outcomes of this work package involved preparation of materials delivered to stakeholders and at industry events at appropriate points during the project. The work package has concluded with the project close down event, which was held on October 4th, in Glasgow, SP Energy Networks headquarters. Refer to section 1.1 (ref 6, 7 and N/A) for Project Direction deliverables.

3.4. USEF Flexibility Trial Methodology

This section provides an expanded account of the activities required to enable and run the USEF flexibility market trial that was carried out in Project FUSION.

Following the completion of work package 3 with the USEF consultation and the USEF Implementation plan for FUSION, project FUSION took a series of steps prior to the trial going live. The main activities can be classified in 3 groups:

1) Procurement and development of the FUSION Flexibility Platform (FFP) and UFTP implementation (Figure 9). See Section 3.4.1 and Section 3.4.5 respectively.

2) Procurement of flexibility services and development of the Aggregator platforms. This includes various activities, such as procurement, recruiting of aggregators, contracting of flexibility through a USEF-compliant Flexibility service agreement, USEF implementation (Figure 10). See Sections 3.4.2 to 3.4.5 for reference.

3) Testing processes process which led to further enhancement and changes of the AGR platform and the FFP prior to going live (Figure 11) and trial implementation process. See Section 3.4.6 for reference.

Figure 9: Procurement, development and testing map process of the FFP

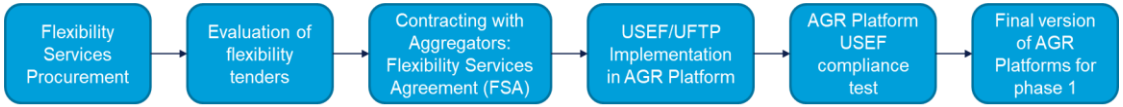

Figure 10: Procurement of flexibility services, development and testing map process of AGR platforms

Figure 11: Testing processes to go-live

3.4.1. Procurement and Contracting FFP

One of the key components for the trial set up and the delivery of flexibility trials in East Fife area is the FUSION Flexibility Platform (FFP) .

Project FUSION developed a series of functional requirements that the FFP should meet, largely based on the USEF process descriptions, addressing both the DSO and CRO roles within USEF. In May 2020 project FUSION published the Platform Communication & Procurement Specification document in order to invite technology solutions providers that could deliver the platform.

The detailed functional requirements can be found in the Specification document[42] and are accessible to all for replication purposes.

Following the procurement process, Opus One Solutions was selected as the FFP solution provider.

3.4.2. Flexibility Procurement Process

Project FUSION's flexibility procurement process consisted of 6 steps:

1) Promote and attract: Project FUSION took a number of steps to promote FUSION flexibility procurement and attract flexible providers. The project team developed several informative documents which were published on SP Energy Networks' website, including:

    a. the flexibility "process map", which provided visibility and transparency to the interested parties of the timeline and the detailed activities of the procurement process;[43]

    b. the Flexibility Service Request (FSR) documents for St. Andrews, Leuchars and additionally five 11kV feeders as part of Phase 2, which articulated the services requirements for the trial in 2021 and was developed to ensure the service windows occurred during normal business hours; [44] [45]

    c. promotional flyer that was mailed to aggregators.[46]

42 USEF Process Implementation Platform Communication & Procurement Specification
43 https://www.spenergynetworks.co.uk/userfiles/file/FUSION_process_map.pdf
44 Fusion Flexibility Service Requisition for Leuchars V1.5
45 FUSION Flexibility Services Requisition for St. Andrews V1.5
46 EOI_Flyer_FINAL_Sep_2021_updated.pdf (spenergynetworks.co.uk)

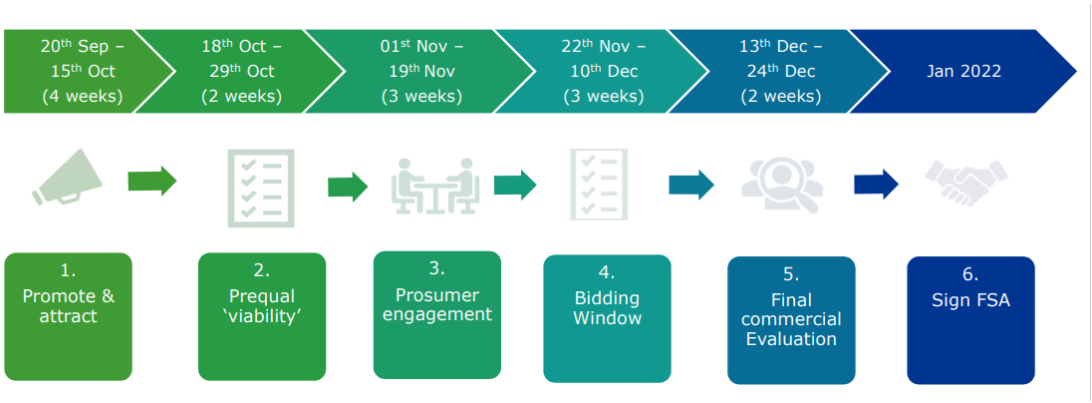

Figure 12 Flexibility Procurement 'Process Map' - Timeline

Following the publication of the documents, SP Energy Networks published the Invitation for Expression of Interest (EoI)[47], which was followed by a dedicated webinar to explain the process and provide clarifications to interested parties. In addition, during this stage, SP Energy Networks asked certain questions to ascertain the extent to which interested parties could comply with the requirements of USEF as well as some other pre-qualification elements.

2) Prequal 'viability': In the second phase, 'prequal viability', through the EoI, Project FUSION firstly identified whether interested parties were or were willing to become USEF compliant or which of the USEF functionalities should be developed. In case of non-USEF compliance, the interested parties could find another party to partner with so they could cover the missing functionalities. Provided that interested parties gave their permission to reveal their identity to other interested parties, SP Energy Networks would introduce non-compliant parties to other parties that could cover those missing functional elements.

3) Prosumer engagement: Another step was to promote engagement between prosumers and the tenderers (flexibility service providers), especially in case that the interested party did not have any flexibility enabled in East-Fife area or they wished to enable more assets than the current ones. Project FUSION invited tendered parties to approach prosumers, engage with them and further analyse their assets and their capabilities. This step was informed by the outcome of project FUSION WP2, whereby the flexibility potential and the potential Prosumers of East-Fife were investigated. Ultimately, this exercise aimed at paring, to some extent and where possible, prosumers (end-users) with the aggregators.

4) Bidding: The bidding process was very similar to Business-As-Usual (BAU) processes. SP Energy Networks issued an Invitation to Tender (ITT)[48] and asked interested parties to provide information about their organisation, their flexible assets and their commercial offer. As part of the response to the ITT, the tenderers were also asked to indicate their technical capabilities to be USEF compliant and ready for Phase 1 of the trial, as well as a high-level indicative implementation plan from award of the contract to operational stage. Alongside the ITT letter, project FUSION developed additional documents to

47 https://www.spenergynetworks.co.uk/userfiles/file/EoI_response_form_v0.1.xlsx
48 https://www.spenergynetworks.co.uk/userfiles/file/ITT%20Response%20Proforma%2020210809v0.2.xlsx

accompany the ITT such as the Flexibility Services Agreement (FSA) template[49] and the tender evaluation criteria.

5) Commercial evaluation: SP Energy Networks performed the commercial evaluation as described in Section 3.4.3.

6) Sign FSA: The successful bidders signed a Flexibility Services Agreement with SP Energy Networks. Section 3.4.4 provides more details on the development of the FSA.

3.4.3. Evaluation Methodology

Project FUSION developed a methodology to select the tender responses that offered the greatest opportunity to explore the main learning objectives of the project and understand how flexibility performs in a USEF-based market. This methodology allowed Project FUSION to select the combination of aggregators and portfolios that offered the best value for money. This exercise was not straight forward due to the low number of Prosumers available in the area, therefore ensuring the presence of more than one aggregator and that portfolios of different aggregators were not overlapping was essential[50].

The assessment method considered several elements to select the most valuable aggregator and portfolio combination for each congestion point. These included the total (£) & unit cost (£/kWh) of the offered flexibility, the average available power across all services and the diversity score based on the mix of sectors and technologies providing flexibility.

The portfolio/aggregator combinations went through the knock-out criteria, which were designed to ensure sufficient learning explore a range of market conditions. The number of aggregators had to be higher than one for each congestion point, to ensure there was some form of competition. The total cost could also not exceed the allocated budget and the average offered power (combining all services) had to be at least what was requested in the FSR.

If exactly one combination had met these criteria, this combination would be selected, and the selection process would end. If more than one combination met all these criteria, then the lowest unit price (90% weighting factor) and highest technology and customer segment diversity (10% weighting factor) would be used.

3.4.4. Flexibility Service Agreement

The Flexibility Service Agreements (FSA) included the full terms and conditions for the provision of flexibility services and defined the responsibilities of and the interactions between the Aggregator and SP Energy Networks. Project FUSION used the ENA's FSA template as the basis for the FUSION FSA and adjusted it, so that it was fit for purpose and USEF compliant. Refinements were made to section 3 of the FSA which describes the Scope of Flexibility Services, and section 5 which describes the monitoring and equipment requirement. The amendments to the FSA were limited only to those deemed necessary to ensure USEF-compliancy; for instance, the DSO must not be allowed to stop a flex order - since in USEF, flex orders are binding. Project FUSION collaborated with TRANSITION on the development of the FSA and definition of flexibility products, which ensured a common approach was adopted to enable more direct comparisons between the projects.

49 Flexibility_Services_Agreement_Template.pdf (spenergynetworks.co.uk)
50 Refer to Section 3.2.3 in ITLR1 for more details of methodology

The FSA template was published as part of the ITT process. The FSA was finalised through bilateral discussion between SP Energy Networks and each of the successful aggregators: Orange Power and Engie.

3.4.5. UFTP Implementation

1 Communication protocol (UFTP)

The USEF Communication Protocol, formally referred to as the USEF Flexibility Trading Protocol (UFTP), describes the interactions and communication exchange between Aggregators and DSO to resolve grid constraints at distribution level. The UFTP covers all phases in the USEF Market Coordination Mechanism (contract, plan, validate, operate and settle) and is designed to be used as a stand-alone protocol for flexibility forecasting, offering, ordering and settlement processes.

The UFTP specifications[51] describe:

- The detailed communication exchange between DSO, Aggregator and Common Reference Operator (CRO) as well as UFTP use cases descriptions derived from the MCM;
- The USEF message descriptions, defining the attributes contained in each Extensible Markup Language (XML) message; and
- The USEF message transport mechanism.

To complement the UFTP Specifications, the USEF Foundation has made available a GitHub page containing the UFTP XSD (XML Schema Definition) files.[52]

During the implementation of the UFTP (by Opus One, Engie and Orange Power) and during UFTP compliance testing, several issues were revealed. These issues were reported to the GOPACS organisation (after the completion of USEF Foundation) that is responsible for maintaining the UFTP protocol and have been resolved in the current UFTP version.

During the course of the project, several further enhancements and change requests were submitted to GOPACS organisation which resulted in UFTP changes. These changes are discussed in in section 5.2, Objective 2.2.

2 UFTP library

Within USEF, a UFTP library has been developed, to streamline and shorten the implementation of UFTP in any platform.

The UFTP message library consists of two parts:

1. An open-source Java software library that can be integrated in the aggregator's own software; and
2. A wrapper around this library that offers an Application Program Interface (API) that enables the aggregator (or any other USEF role) to communicate to other USEF roles according to the UFTP messaging scheme.

This library is open-source and accessible to all aggregators to facilitate the UFTP implementation in their systems[53]. Section 3 presents a high-level description of the UFTP

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51 https://www.usef.energy/app/uploads/2020/01/USEF-Flex-Trading-Protocol-Specifications-1.01.pdf
52 https://github.com/USEF-Foundation/UFTP
53 https://github.com/shapeshifter/shapeshifter-library-java

implementation by aggregators, including whether they used the library and the benefits it brought them.

3 UFTP implementation by Aggregators

To implement UFTP in their systems Orange Power used Kanban at GitHub as the coordination tool between Orange Power's software developers and UFTP's specifications. Orange Power developed their own coding to match UFTP specifications and tested its implementation through the use of the DSO simulator. Orange Power used the UFTP library as a reference, but not directly as their codebase.

Orange Power also used the DSO simulator (described in section 7) and they found it very useful as they could use it as a testing tool. They also indicated that using the DSO simulator saved testing time and facilitated early identification of potential issues.

Engie (represented by Gridimp) implemented the UFTP in a cloud-hosted layer. The internal communications for dispatches and metering between their onsite appliance devices and their cloud remained unchanged. In practice this means that all DERs connected to their hub can now participate in any USEF contract.

For their implementation Engie used the UFTP library. Engie found the library beneficial because:

- it allowed them to start from a common agreed baseline implementation;
- it saved time; and
- after implementing the UFTP library, they could make the modifications that suited their needs.

Engie also used the DSO simulator (described in section 6, 7) as a counterpart to test their own communication.

4 FUSION Flexibility Platform (FFP)

The FUSION Flexibility Platform was implemented by Opus One as the successful bidder in the procurement process described in section 3.4.2.

To execute the project, Opus One developed and deployed its software solution, GridOS® to serve as the basis for the FFP. The solution developed had to be USEF compliant. Since being awarded this project, Opus One, SP Energy Networks, and DNV engaged in numerous technical workshops to facilitate the delivery of design as per the FUSION requirements. These workshops have focused on various topics including:

- USEF Compliance
- SP Energy Networks' System Integration
- Market Coordination Mechanism (MCM) Stage Process Flows
- Network visualization
- User Flows and Experience
- Flexibility service metering
- Long and Short-term load forecasting
- FUSION trial market services
- FFP testing strategy

- Aggregator engagement

Opus One developed three iterations of the Detailed Design Specification (DDS), following feedback from SP Energy Networks and DNV. During software development, Opus One and SP Energy Networks continued to engage in technical discussions to support the delivery of the project.

Opus One developed a tailor-made FUSION solution, identifying in collaboration with SP Energy Networks and DNV all the flows by which each of the USEF roles are expected to interact. Four process flows were outlined, explaining how the components of the system would engage and interact to realise each of the MCM stages and how data transfers would facilitate this.

There are four key entities that comprise the FUSION solution, as visualized in Figure 13. These are:

1) Constraint Management Service Provider (CMSP)
2) Common Repository Operator (CRO) Module
3) Distribution System Operator (DSO) Module
4) SP Energy Networks Systems

Appendix 2 – Roles and responsibilities includes a description of these roles as per USEF and their correspondence with roles in GB market.

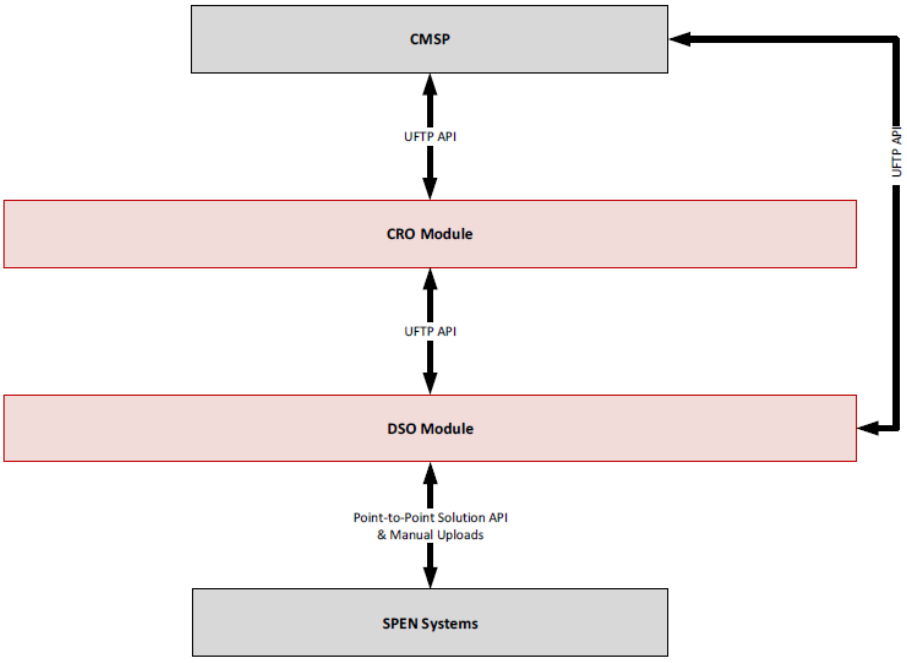

Figure 13: FUSION Solution Systems

In addition, through the technical workshops Opus One worked with SP Energy Networks and DNV to determine the process flows associated with the FFP solution to meet the user flows and functional requirements. The solution architecture consisted of Architecture diagrams (detailing the internal components of the solution and their services), Integration (between SP Energy Networks systems and the FFP solution), data models, and cybersecurity requirements. The figure below details the high-level solution service architecture.

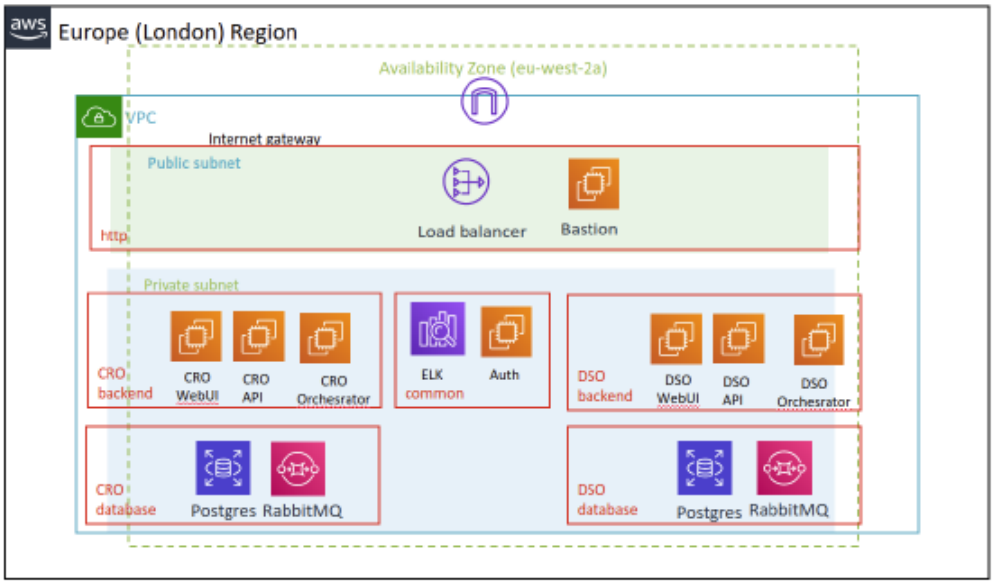

Figure 14: High-Level Service Architecture[54]

5 FUSION simulators

One DSO simulator and one Aggregator simulator were used in project FUSION. These simulators provided two benefits:

- They allowed both Opus One and the aggregators a test environment, both to test their own respective systems and to validate whether their UFTP implementation was working according to the specifications, without having to rely on the other party (aggregator / Opus One) that was developing their system in parallel.
- It allowed a third party (in this case DNV) to test UFTP compliance, ensuring a smooth integration between the DSO platform (developed by Opus One) and the Aggregator platforms.

6 Aggregator simulator

OrangeNXT created a simulating environment for aggregators which could be used within FUSION. This was an "as-is" implementation and gave access to all the functionalities that were already developed and that are currently being used by Dutch DSOs. The endpoints of the aggregator (AGR) simulator were configured to support a connection to the FFP and the Fusion Common Reference Operator (CRO) environment. A settlement period of 30 minutes was also configured.

The "as is" version of the AGR simulator was further improved following discussions between OrangeNXT and SP Energy Networks. The two main developments were the inclusion of the Metering and Settlement messages in the OrangeNXT's AGR simulators. The inclusion of this functionality was based on the USEF Flexibility Trading Protocol Specifications.[55]

During the course of the project, the AGR simulator was demonstrated to be an effective tool for allowing non-USEF-compliant aggregators to interface with the FFP and thus participate in a USEF market, without the aggregator having to develop their own USEF-enabled interface.

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54 Source from GOPACS (ex-USEF Foundation)
55 https://www.usef.energy/app/uploads/2020/01/USEF-Flex-Trading-Protocol-Specifications-1.01.pdf

7 DSO simulator

OrangeNXT delivered a DSO simulator (i.e., simulator of the FFP). Some of the functionalities of this simulator were already developed and FUSION got access to them for the purposes of testing. The DSO environment was further configured for project FUSION.

The DSO simulator was further improved following discussions between OrangeNXT and SP Energy Networks. The two main developments were the inclusion of the Metering and Settlement messages in the OrangeNXT's DSO simulator. The inclusion of this functionality was based on the USEF Flex Trading Protocol Specifications.

3.4.6. Testing Processes

Project FUSION developed a FUSION testing process before the trial went live. The tests that were performed are:

- Factory Acceptance Test (FAT)
- Site Acceptance Test (SAT)
- Aggregator USEF compliancy test
- User Acceptance Test (UAT)
- End-to-end integration test
- Commissioning test (CT)

Detailed information on the testing processes can be found in ITLR#1, Section 3.4.

3.4.7. Trial Live

Phase 1

The first phase of FUSION trial went live in September 2021. In phase 1 there was no congestion affecting the substations and feeders. Congestion was simulated and the use cases were designed so that flexibility would be dispatched almost daily to respond to a series of 13 x plausible events[56].

The test cases that were simulated and tested throughout the trial phase 1 period are presented in section 2.3 of ITLR#2. These test cases explain the logic that the DSO follows to trade flexibility, i.e., to request flexibility from the aggregators and then order it if it is required (i.e., issue a FlexOrder). It is worth noting that the simulations were executed according to a schedule that was designed to ensure that all test cases were trialled and that a high turn-over of events

56

USE CASE	*TEST CASE*	
Secure DSO Constraint management (pre-fault)	*1.1*	*Reserve + Order*
	1.2	*Reserve + No Order*
	1.3	*Free Bid + Order*
	1.4	*Free Bid + No Order*
	1.5	*FlexReservationUpdate*
Dynamic DSO Constraint Management (post-fault)	*2.1*	*Reserve + Order*
	2.2	*Reserve + No Order*
	2.3	*Free Bid + Order*
	2.4	*Free Bid + No Order*
	2.5	*FlexReservationUpdate*
Sustain Peak Management	*3.1*	*Reserve + Order*
	3.2	*Free Bid + Order*
	3.3	*FlexReservationUpdate*

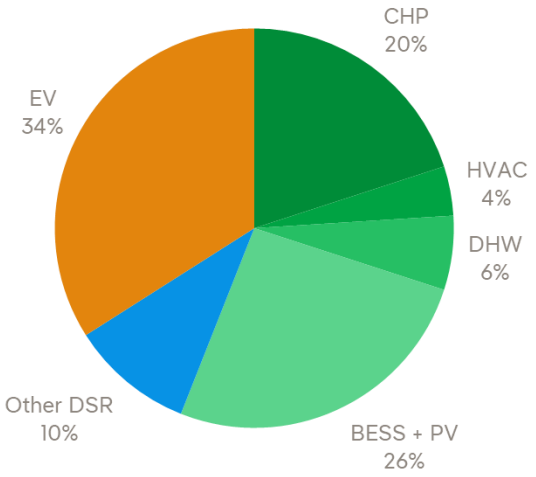
were achieved to maximise the volume of relevant empirical data generated for subsequent analysis within the boundaries of the contracts.

To simulate events closer to real conditions in phase 2 of the trial, only the maximum power threshold at substation or feeder level was modified, instead of the forecasts (as we did in phase 1). In this way, the original grid forecasted profile was used and the full functionality of the FFP utilised. This is also discussed in section 6.3.

Phase 2

Project FUSION trial phase 2 started in April 2022. In comparison to phase 1, the design of the second phase of the FUSION trial was adapted to test the effectiveness of real time forecasts from the DSO, instead of the simulated forecasts that were used in phase 1. The main difference between phase 1 and 2 is that for phase 2, real time forecasts from the DSO were used instead of the simulated forecasts used for phase 1. As such, the test cases needed to be adapted incorporating the steps for the DSO to take into account the real-time developments. The test cases are summarised in ITLR#2, section 2.3.1

The following figure provides a breakdown of the flexibility capacity, contracted in phase 2, by technology type[57]



57 Combined Heat &Power (CHP), Heating Ventilation & Cooling (HVAC), Domestic Hot Water (DHW), Battery Energy Storage System (BESS), Photovoltaics (PV), Demand Side Reduction (DSR), Electric Vehicles (EV).

4. Project Outcomes

4.1. Key Findings from USEF Innovative Elements

For each USEF Innovative Element (UIE) that was tested, each section provides a description of the key message, the UIE that was tested and summarised analysis beneath it.

4.1.1. Market Co-ordination Mechanism

UIE 1 tested: Market Coordination Mechanism (MCM) – a standard approach to flexibility trading consisting of five phases – contract, plan, validate, operate and settle.
UIE 1 Findings: • A standardised process benefits all market participants. A standardised process benefits all market participants. • Features such as day ahead trading can increase reliability of flexibility. • Day ahead trading struck the best balance giving customers visibility of when their assets will be utilised and not restricting how to use them.

Analysis and Observations

Experience with MCM: The MCM was implemented through the FUSION Flexibility Platform developed by OpusOne. Aggregators considered the MCM useful, clear and well structured, as they benefit from only interacting with one system for all phases of flexibility delivery.[58] In addition, it was reported that MCM's trading flow is effective in understanding the grid requirements and consumer's availability.

Reliability of Delivery: FUSION trial achieved approximately 80% overall reliability[59] of USEF-based flexibility in phase 1 and 2 (Figure 15). This performance is in average 15% higher compared to other DSO flexibility trials [60]. Although there is not enough evidence to definitively establish a causal relationship between the MCM and increased reliability, it is worth noting that the MCM has certain features that are likely to have contributed to this high reliability:

USEF allows portfolio bids which would enable more flexibility to aggregators to choose assets that are available in the moment of delivery as well as the diversification of assets to provide a service. [61]

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58 During the trial, the contract phase was populated at the procurement stage whereas the phases from 'plan' to 'operate' were conducted day-ahead and intraday.

59 Reliability of delivery was calculated by summing all delivered flexible energy during the trial and dividing it by the total ordered flexible energy (Eq 1). Total trial reliability includes ordered and delivered flexibility in Phase 1 and Phase 2 from September 2021 to March 2023.

$$Flexibility\ Delivery\ Reliability = \frac{\sum Delivered\ energy\ in\ ISP}{\sum Ordered\ energy\ in\ ISP} \quad \text{(Eq 1)}$$

$$Flexibility\ Delivery\ Reliability = \frac{48.3\ MWh}{60.9\ MWh} = 80\%$$

60 See table 14 of ITLR#4. Trials include TRANSITION & LEO project, Cornwall LEM, ENTIRE
61 Allowing portfolio bids instead of flexible asset bidding provides greater flexibility to aggregators to choose available flexible assets for dispatching flexibility and meeting DSO flexibility requirements. For example, when the process is asset agnostic, the aggregator can dispatch any asset (e.g., EVs or heat pumps or a CHP). If portfolio bidding is not allowed, and the aggregator has to dispatch pre-defined assets, then in case that the asset is not available, there is a risk of under-delivery and less reliability of flexibility.

allows shorter timeframes for flexibility trading which allows representation of the close to real time status of the flexible assets.[62]

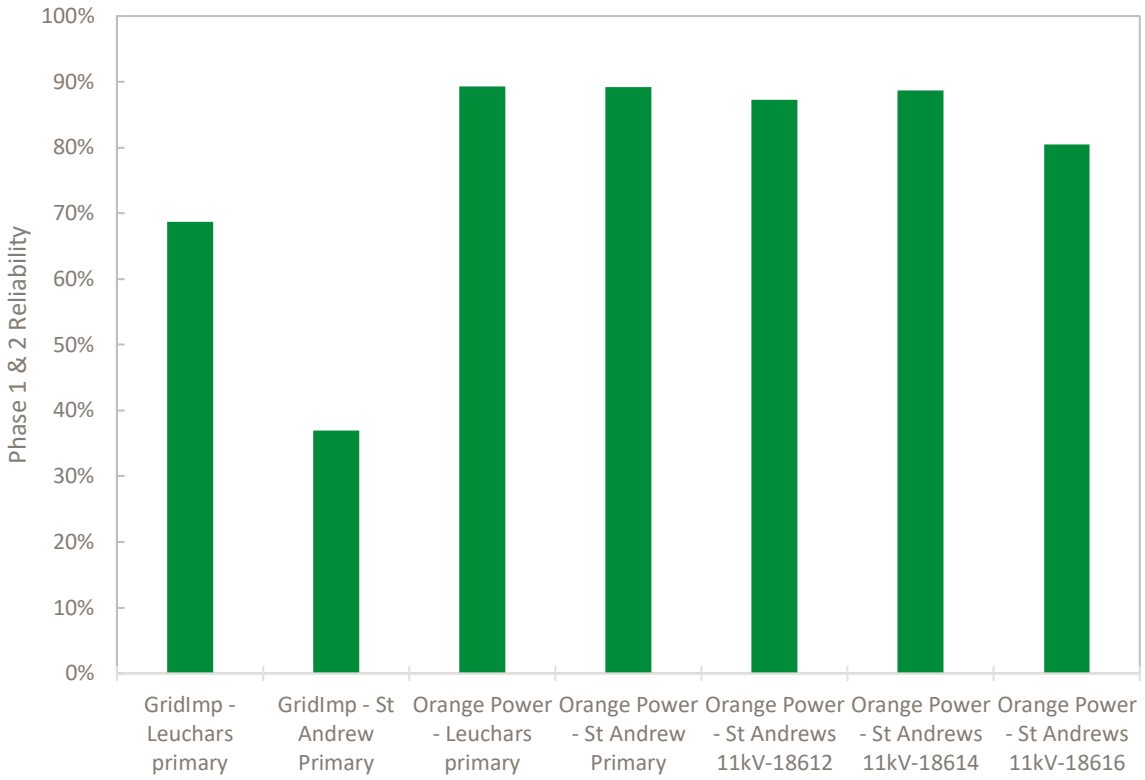


Figure 15 Phase 1 and 2 Reliability for Each Aggregator and Congestion Point

Procurement Efficiency: The MCM also improved flexibility procurement efficiency[63]. Flexibility is procured in a shorter timeframe, allowing the DSO to have a more accurate view on the grid needs. USEF enabled a 1-3% reduction in the DSO's need for flexibility to account for potential forecasting errors. Although this improvement is small and could also fall within the margin for error limits, the forecasting of network demand is likely to become more challenging as more stochastic low carbon technologies are connected to the system. The benefit of shorter procurement timeframes may therefore increase in the future. Aggregators reported that ordering day ahead struck the best balance giving customers visibility of when their assets will be utilised but not restricting what they can do with them.

Rebound Effect: USEF's MCM includes structured processes to take into account the rebound effect of flexibility activation and adjust flexibility procurement to account for this effect. Although in the trial the rebound effect was not tested, project FUSION studied the potential impact of rebound effect on flexibility procurement volumes. The project has calculated a theoretical rebound impact that a future representative portfolio (based on FUSION partners'

62 Shorter timeframes of FUSION are defined as day ahead and intraday and are compared to week ahead procurement of BAU flexibility. The impact of shorter timeframes on reliability is twofold: 1) It enables shorter timeframes for the DSO to have a more accurate view on the grid needs and request 2) it allows aggregator to have better visibility and control their flexibility assets. However, it is worth mentioning that although day-ahead considered beneficial by the aggregators for having better visibility, moving closer to the real time (e.g., intraday) is still a barrier as they encounter difficulties in controlling their assets and changing their demand/ generation pattern intraday.

63 DSO efficiency refers to flexibility procurement efficiency and is used as a metric of whether the DSO has procured as much flexibility as required or if the DSO has over procured flexibility (i.e., increase procurement costs without really flexibility requirements).

experience and literature review) would have in East Fife congestion points. [64] The results indicate that ~20% more flexibility would need to be activated to counteract the negative impact of rebound. For future research, project FUSION recommends making an empirical analysis on rebound effect.

Enhancements: Aggregators have suggested several enhancements to the MCM. These include the automation of the settlement process, reducing the time between stating the contracted availability capacity and delivery from six months to a shorter period, and providing more transparency regarding the bid selection criteria. Importantly, these improvements can be implemented while still adhering to the USEF guidelines.

The detailed analysis of MCM and the quantitative assessment of the objective is included in ITLR#4, section 4.1.3.

Next Steps

Standardisation across DSO flexibility markets has been discussed a lot across the industry and is also pursued through Energy Networks Association (ENA) and Open Networks. FUSION's learnings and experience with MCM can help to inform UK's journey towards a common flexibility trading standard.

4.1.2. USEF Flexibility Trading Protocol

UIE 2 tested: The USEF Flexibility Trading Protocol (UFTP), describes the interactions and communication exchange between aggregators and DSO to resolve grid constraints at distribution level
UIE 2 Findings: • Automation of flexibility trading processes make the trading as frictionless as possible • Automated process enable aggregators to manage large portfolios of small assets, which otherwise would be more time consuming and costly

Analysis and Observations

Experience using UFTP: The MCM was implemented through the FUSION Flexibility Platform developed by OpusOne. Both aggregators consider the UFTP has worked smoothly throughout the phases of the trial, with communication being timely and straight forward. Aggregators reported that implementing the protocol encouraged them to also assess and improve their own processes.

Aggregators found the automation of the flexibility trading processes made trading as frictionless as possible, enabling them to manage large portfolios of small assets, which otherwise would be more time consuming and costly.

There was also awareness of the fact that the UFTP is perceived as complex. UFTP enablement costs were estimated at £150k (£87k for the DNO and £30k by each of the two aggregators), which demonstrate the complexity of developing the necessary systems. However, aggregators suggest that the UFTP has a similar level of complexity as other standards that automate the end-to-end processes.

64 ITLR#4, section 4.1.3 includes the details of our methodology on rebound effect. The representative portfolio includes flexible assets such as EVs, heat pumps, battery+solar, other DSR, CHP, HVAV.

SP Energy Networks did not report experiencing any issues using the protocol throughout Phase 1 & 2. They suggested that in the future it would be beneficial to trial an automated process for sending FlexRequests. This is something that UFTP enables and could be implemented in the FFP but was not taken forward during FUSION trial due to time constraints.

Settlement process: A more automated settlement process would also be beneficial but challenging due to the high number to features that must be considered. Project FUSION performed settlement processes manually via an excel spreadsheet because settlement functionality was not integrated in the FFP due to some limitations of the platform. Additionally, the UFTP only covers the utilisation payment linked to FlexOrders; it does not cover availability payments or account for the aggregator performance. [65] Hence, aggregated suggested that availability payments be added to the protocol. This suggestion has not been formally submitted yet to SHAPESHIFTER.

Interactions with SHAPESHIFTER TSC: One of the highlights of Project FUSION has been continuous engagement with the Technical Steering Committee (TSC) of SHAPESHIFTER (under LF Energy) to provide feedback on issues that the project encounters. SHAPESHIFTER has approved a change submitted by the FUSION project to solve an issue raised by OpusOne (FFP provider) and has also approved changes submitted by Gridimp on the structuring of messages related to metering and service types. These changes are explained in section 5.2, objective 5.

More details on the UFTP can be found in ITLR #4, section 4.1.5. [66]

Next Steps

Automation and end-to-end platforms are another important theme in the sphere of flexibility markets. This is something that has been highlighted by Ofgem in the recent Call for Input: The Future of Distributed Flexibility. [67] Considering the benefits that automation can bring in the flexibility trading processes as report by FUSION, FUSION's learnings and experience with the UFTP could help to inform the development of a highly automated end-to-end platform.

4.1.3. Common Reference

UIE 3 tested: Common Reference (CR) – repository that contains detailed information on network congestion points, associated connections, and active aggregators in those connection points.
UIE 3 Findings: • A standardised data set that maps congestion points against connections and assets, provides increased market transparency and DSO visibility on active aggregators, compared to flexibility markets which operate with the absence of such a dataset and information exchange process. • The automation and smooth process of onboarding new assets is critical for aggregators

Analysis and Observations

65 Validation of the flexibility delivery and settlement are performed manually. DNV developed a number of SQL scripts to assist the manual validation and settlement of delivered flexibility. These scripts extract data directly from the FFP database and can be used to compare aggregated meter data over several days, and also to calculate the delivered flex per day for each aggregator and congestion point. Exporting the extracted data to a spreadsheet allows a flex settlement report to be generated.
66 https://www.spenergynetworks.co.uk/userfiles/file/Interim%20Trial%20learnings%20Report_Dec%202022.pdf
67 Call for Input: The Future of Distributed Flexibility | Ofgem

The use of CR enhances transparency by allowing aggregators to get the information on the congestion points where they are active (and only those for confidentiality and privacy reasons). It also allows the DSO to get visibility on the aggregators operational at their congestion points.

Both SP Energy Networks, in their role as the Common Reference Operator, and the aggregators who used the platform have had a positive experience. In particular, the participants appreciated that CR:

- enables information access and facilitates information sharing between parties
- Has improved security and encryption measures in place compared to other platforms
- automates and smooths the process of onboarding new assets by not requiring pre-qualification and by the automated processes. This is particularly important for aggregators with large portfolios of small assets.

Insights gained from utilizing the CR should be prefaced with recognition of the limited number of FUSION trial participants. Future testing on a larger scale would provide a more definitive demonstration of the solution's scalability.

FUSION did not explore applying CR at national level, but aggregators suggested that coordination between the CR and ESO requests would potentially further enhance value stacking.

The findings of the use of the CR in FUSION trial are discussed in detail in ITLR#3, section 4.1.

Next Steps

- ❑ If the concept of the Common Reference was transition to BAU a separate entity could take on the role of CRO following an appropriate due diligence process to ensure the data is stored, handled and processed appropriately in order to maintain data security and privacy throughout.
- ❑ CRO can be extended towards the ESO allowing improved ESO-DSO coordination.

4.1.4. Baselining Design

UIE 4 tested: Baseline Design - FUSION Nomination Baselines (i.e., D-programmes): the forecast of the generation or demand profile of the asset or portfolio if no flexibility activation were to take place
UIE 4 Findings: • Baselining Accuracy is a constant challenge for aggregators, including nomination, historical and MBMA baseline methodologies. • All methodologies performed poorly in FUSION trial. • Baseline inaccuracy leads to a bandwidth for service delivery and is one of the factors that increase DSO procurement costs or endanger the effectiveness (reliability) of congestion management

Analysis and Observations

Accuracy of nomination baselining methodologies: The overall accuracy of the D-programmes was poor when compared to what the literature defines as "good" or "acceptable" baseline methodologies. The baselining performance of aggregators is very much linked to the methodologies that they used for baselining and for forecasting their load.

Gridimp's performance: Gridimp used the historical New England baseline method[68], which led to significant error as the expected demand was set at a constant value for whole days at a time and only reviewed infrequently. Following a number of iterations and improvements Gridimp's baseline accuracy improved to a range between 33% and 71% Relative Root Mean Square of the Error (RRMSE) and the bias improved from 178% to -23% at the end of the trial across the two congestion points from phase 1 to phase 2. The initial accuracy of Gridimp's baseline at the beginning of the trial was -275% RRMSE.[69]

Orange Power performance: Orange Power's forecasting method consists of forecasts per technology supported by machine learning algorithms which produced the forecast of usage and generation pattern of each flexible asset. OP struggled initially with data feeding issues and with allocating resources to focus and improve baselines. The accuracy of Orange Power's (OP) baseline, for the period studied, ranges from an RRMSE of 63 to 183% across the different congestion point.

The accuracy shown by the D-programmes varied per portfolio type. For example, OP's portfolio at Leuchars which includes EV chargers and other residential assets had the most accurate baselining out of all of them, at a 63% RRMSE.

Accuracy of other baseline methodologies: The accuracy and bias of the baselines in the trial were compared with the ENA's online historical baseline tool. The comparison showed that ENA's tool was slightly more accurate and had less bias. Nevertheless, the historical baseline is still also not able to achieve a baseline accuracy that is considered "acceptable" at all congestion points except one (Figure 16).

Project FUSION also assessed the accuracy of meter before and meter after (MBMA). MBMA performed better than historical and nomination baselines (RRMSE range of -160% to 20%), but still "not acceptable" according to industry standards (Figure 16).

68 The New England (NE) baseline is a baseline used from flexible assets which participate in New England's SO services (US). This is a historical baseline which is one of the most common baselines and have been widely adopted by other countries and flexibility services as well. This is why the name NE baseline is still used. For the creation of the historic baseline a 10-day average is taken from the past 30 non-holiday weekdays. For weekends and holidays a 5 day average is used looking back to 42 calendar days (weekends and bank holidays).

69 RRMSE is a metric to evaluate the accuracy of the baselining methodology. Accuracy was measured by the relative root mean square of the errors (RRMSE). Based on the literatura review of baseline methodologies that DNV had conducted, RRMSE of 10% or les are generally considered "Good" and RRMSE between 10% to 20% is considered to provide "aceptable" accuracy. ITLR3, SECTION 4.4.2 includes the detailed methodology for calculating the RRMSE.

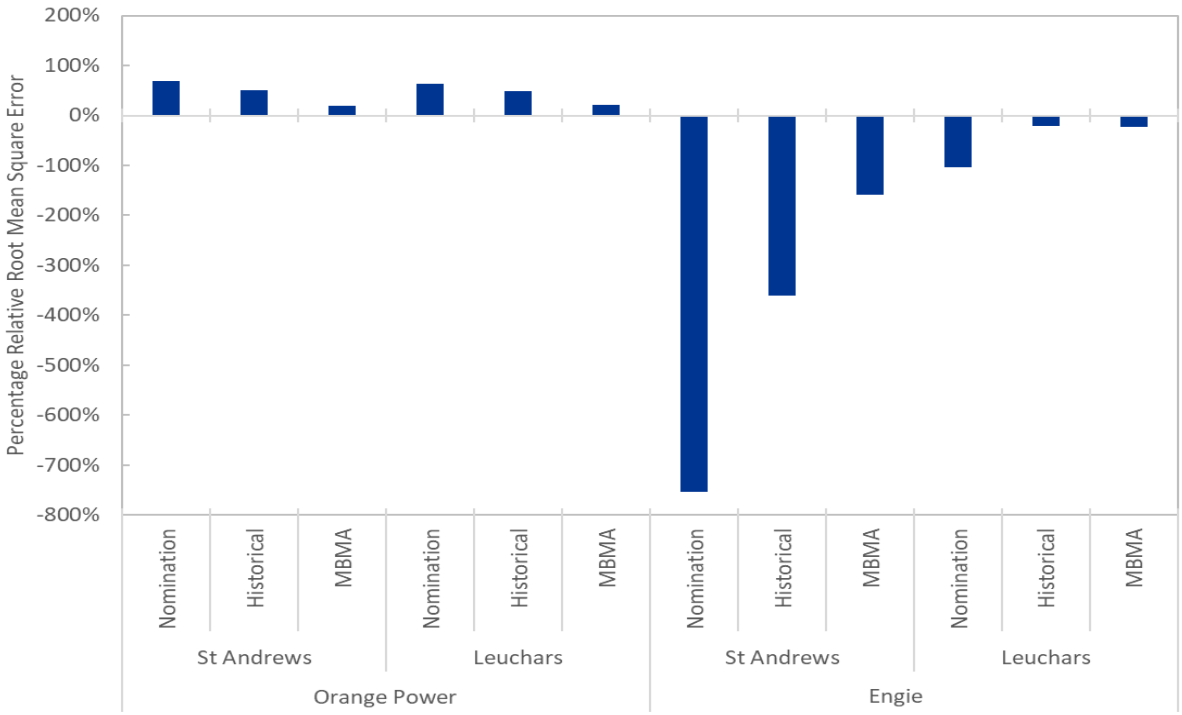


Figure 16 Comparison of RRMSE for Nomination, Historical and MBMA Baselines

Simplicity of nomination baselines: Nomination baselines are in general considered simple in implementation as they require a forecast methodology of the demand/generation of the asset and it relies on aggregators to develop the methodology, instead of using a pre-defined method. The level of simplicity in phase 1 was rated high by aggregators. In phase 2 the level of effort has increased as the aggregators trialled alternative approaches to improve the accuracy of their D-Programme including, adding a manual check to verify and amend the output of the machine learning algorithm. While this has reduced the simplicity of producing the baseline, the accuracy has improved - although it was still poor. While this has reduced the simplicity, it shows aggregators capitalising on one of the main strengths of nomination baselines: the ability to adapt and change the methodology based on knowledge of the assets.

Inclusivity: Some baselines are technology-agnostic and suitable for (almost) all technologies, whilst some other baselines may be applicable or accurate only for certain technologies, consumer types and portfolios of assets. Nomination baselines are considered highly inclusive as they allow flexibility providers to provide forecast of the generation/demand based on any calculation methodology which suits their flexible assets and taking into account all relevant and available data. The aggregators participating in the trial confirmed this observation and have indicated that they are positive about the use of D-programmes since it allows to baseline the diversity of assets in their portfolios.

The findings on baselining design in FUSION trial are discussed in detail in ITLR#3, section 4.4 and ITLR#4, section 4.1.2.

Next Steps

FUSION recommends DSO and aggregators incorporating on-going monitoring of the baseline accuracy in a standardised way across DSOs to:

- ❑ Provide feedback to aggregators and investigate where improvements can be made

- ❑ Understand the baseline impact on flexibility delivery and network impact
- ❑ Not associate monitoring with penalties initially as this would increase the barrier for participation for aggregators. When liquidity in the market is achieved, it can be considered whether baselining requirements should be specified in the FSA contracts.

4.1.5. D-programmes

UIE 5 tested: D-programmes are aggregator forecasts at asset level of their future electricity demand/generation that are sent to the DSO to enhance the visibility of their network.
UIE 5 Findings: • There is no urgent need to improve existing 11kV DSO forecasting due to its high accuracy. • Greater visibility of Low Carbon Technologies (LCTs) demand and generation behind the meter could potentially contribute towards improving forecasts for flexibility in LV networks, where the DSO has very limited visibility.

Analysis and Observations

Project FUSION analysed how D-programmes could be integrated into the current forecasting processes and investigated the DSO forecast accuracy at substation level.

Existing forecasting processes: The current forecasting methodology is based on the PRAE forecasting tool and predicts the load at substation level up to five days in advance, based on historical measurements. The measurements are updated every half hour and the forecast is enhanced with the latest information. Generation is only accounted separately when there is front-of-the-meter generation. Analysis showed the current DSO substation forecast is highly accurate (estimated 2-3% of error) and therefore the scope for D-programmes to improve DSO forecast at 11kV on the flexibility activations day ahead was too small to warrant the effort required to achieve it.

I**ntegrating D-programmes into existing DSO forecasting processes**: It is worth noting that FUSION trials could not integrate D-programmes into substation load forecasting, because this required aggregators to communicate real-time sub-meter data which could be costly to implement for project FUSION. In addition, the current DSO forecast looks into 5 days in advance, but the D-programmes are only submitted day-ahead. This means that USEF forecast would need to include different forecasting methodologies to inform forecasting for longer periods of time (i.e., 5 days ahead).

Future use of D-programmes: D-programmes and other type of information (such as asset type, capacity, etc) could greatly contribute towards improving forecasts for flexibility in LV networks, where the DSO has very limited visibility, especially with the increased penetration of behind-the-meter technologies. Please note that behind the meter technologies are not taken into account separately by existing forecasting methodologies. This is because forecasting at substation level only takes into account the load and the front-of-the-meter generation, whereas all generation behind the connection is hidden for the DSO. Having visibility of forecast of distributed PV, or other types of generation would enhance the forecast specially at lower voltages (lower than 11kv).

The findings of the use of the D-programmes in FUSION trial are discussed in detail in ITLR#2, section 4.3.

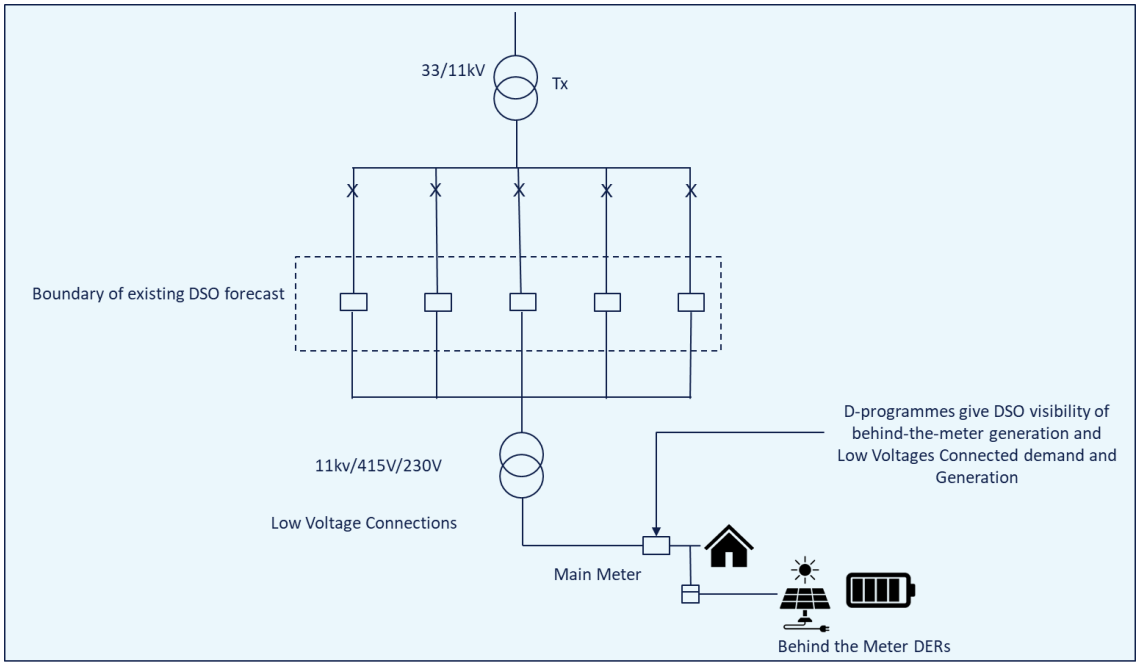


Figure 17 Topology of existing DSO forecast Voltage level versus D-programmes LV level

Next Steps

- ❑ As discussed, project FUSION does not foresee an urgent need to improve existing 11kV DSO due to its existing high accuracy. In the future, and as more LCTs and behind-the-meter generation are connected to distribution network, DSOs could consider forecasting approaches at LV networks and potential enhancements with a concept such as D-programmes.

4.1.6. Free bids

UIE 6 tested: Free bids– Offers of flexibility (i.e., FlexOffers in USEF terms) which aggregators send in response to a request for Flexibility (i.e., FlexRequest in USEF terms) from the DSO that is either outside of their contracted availability window or above their contracted power capacity .
UIE 6 Findings: • Ultimately, the trial has shown that the flexibility bidding of non-firm assets outside contractual windows (discretionary bids) could work as a concept, would encourage non-firm asset participation, and improve reliability of flexibility. • However, the current market and payment structures are not mature enough yet to fully leverage this mechanism.

Analysis and Observations

FUSION set out to explore whether: free bids encouraged participation in flexibility markets from a wider variety of assets (mostly non-firm assets). It also explored whether free bids increase reliability of flexibility, whether they improve the business case of FSPs operating non-firm technologies and looked into the effect of pricing on free bids.

Free bids as a commercial mechanism: Aggregators' feedback was that free bids could contribute to making more flexibility available and attract new customers, because it enables non-firm assets to offer flexibility outside contractual arrangements. This is particularly relevant for first time end-users as they are able to join the vent freely without needing to commit to long-

term contracts. In the future, when flexibility is participating in different markets, the dynamic element of free bids will be key to enable optimisation of flexibility across different markets. Aggregators also confirmed that free bids could have positively impacted their business case by enabling additional revenue from non-firm capacity and opportunities for value stacking in the future.

However, the current contractual arrangements and payment structures disincentivised aggregators from issuing free bids. Aggregators' focus on the trial was to fulfil their obligations on availability and get the payment through the availability contract. The non-delivery/non-availability of flexibility under availability contract penalises aggregators, and logically they are incentivised to solve this problem.

For Gridimp it was not plausible to focus on free bids while they were having issues with normal service delivery, and they did not have any extra unused capacity. In addition, Gridimp has signalled that since their flexibility trading is fully automated, with the system responding to requests in the same manner regardless the time of the day or the requested power. The only occasions in which Gridimp has purposely provided free bids was when SPEN asked for them explicitly.

Orange Power did send free bids; however, they also did not fully explore the mechanism possibilities, even with the amount of extra enabled capacity, due to the following reasons:

- There is no clear view on the extra available capacity due to lack of short-term portfolio monitoring, which makes it challenging for the aggregator to have a detailed view on the spare capacity that is outside the availability contract.
- The utilisation prices received from free bids were not attractive enough to motivate the aggregator to investigate free bids further.
- The aggregators are mostly focused on fulfilling their contractual obligations, since this has a significant impact on their availability payments which makes up the greatest share of their remuneration.

Pricing of free bids: In Phase 2 of the trial, FUSION observed that raising the free bids price cap had a positive effect in raising public interest (from aggregators' customers) on flexibility and was a good incentive to encourage participation. However, even if increased, aggregators indicated that it was still low given the current energy crisis context. This highlights once again the importance of opportunity costs when it comes to flexibility. If this flexibility can participate in other mechanisms with higher utilisation remuneration, aggregators will bid in those markets rather than offering free bids to the DSO. Therefore, if the DSO wishes to rely on free bids for solving congestion, the bid price would need to be higher than the opportunity costs. Our quantitative analysis also confirms our qualitative observations, as it shows that aggregators priced free bids at a higher price than normal bids at all congestion points where both were used.

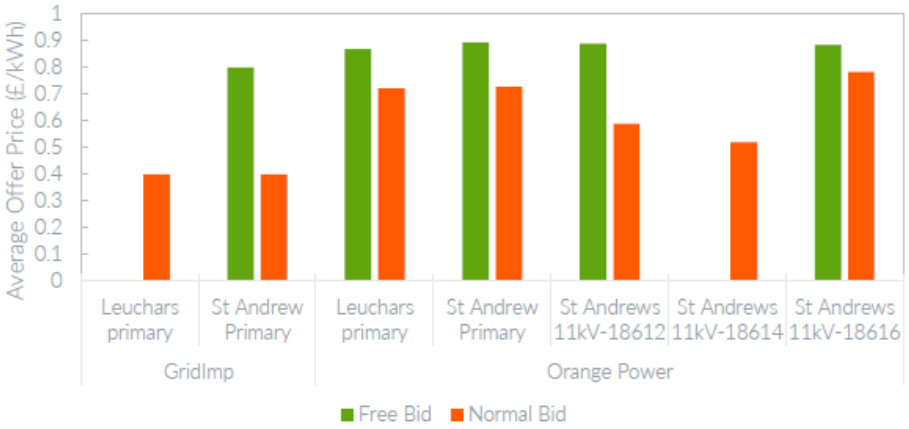


Figure 18 Comparison between offer price of free bids and normal bids

Use of free bids and impact in reliability: Analysis showed that one aggregator (OrangePower) offered additional flexibility above their contracted capacity on several occasions (see Figure 19). As the contracts were signed 6 months ahead of delivery, aggregators were cautious about how much flexibility they offered in them. Orange Power (the aggregator that offered additional flexibility) continued to recruit more assets after the availability contracts were finalised. As such, they then were able to offer more flexibility than in their contract. Although they missed out on the high availability fees, they could still be paid for utilisation of the asset via free bids. This aggregator had a greater pool of enabled assets and was more actively looking for ways to get remunerated for their flexibility. On these occasions that the aggregator issued free bids, the average extra flexibility offered totalled 611kW across all congestion points in addition to 941kW of contracted flexibility. This means that when aggregators issued free bids, they could offer 64% more flexibility than the contracted volumes, which would otherwise be underutilised. As a result, if the DSO was to rely on free bids to meet flexibility requirements, it could have saved 64% (i.e., 611/941 %) on their availability costs. However, this is a long-term scenario where the concept of free bids and the reliability of their flexibility would have been well established and tested, in order to provide sufficient confidence for the DSOs to rely on free bids' flexibility for congestion management.

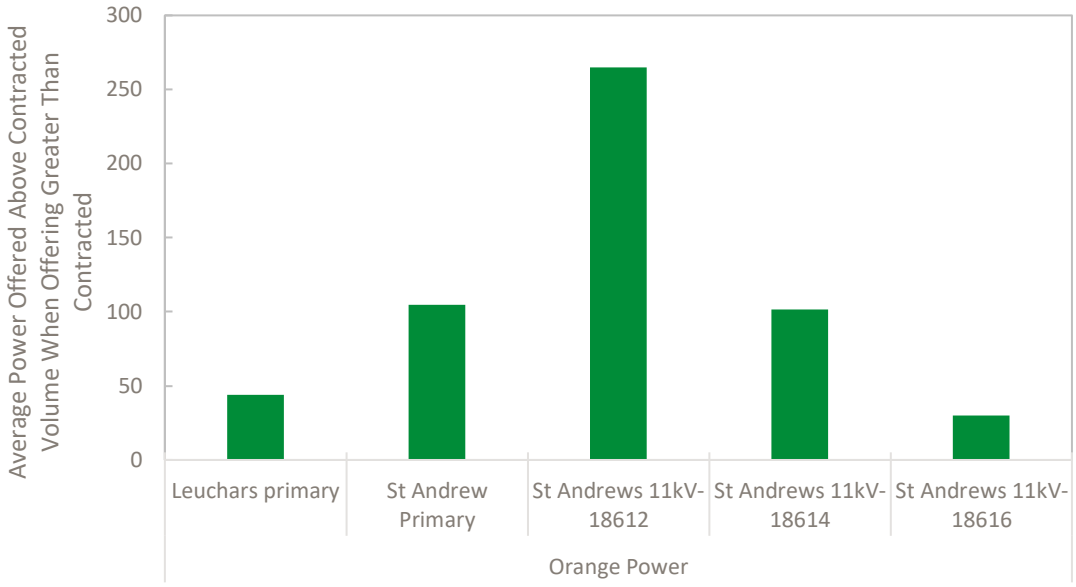


Figure 19 Average power offered above contracted volume when offer exceeds contracted volume

Ultimately, the trial has shown that the free bidding concept works but the current market and system was not mature enough yet to fully leverage this mechanism.

The findings on free bids mechanism in FUSION trial are discussed in detail in ITLR#3, section 4.3 and ITLR#4, section 4.1.1.

Next Steps

- ❑ Project FUSION suggests that DNOs and aggregators consider the potential benefits of USEF features such as free bids (or discretionary bids) and how they could be integrated into the existing DSO flexibility market arrangements and what kind of contractual arrangements and payments structure would lead to a higher utilisation of free bids.

4.1.7. Sub-metering arrangements

UIE 7 tested: Sub-metering arrangements for assets participating in DSO services
UIE Findings: 7 Sub-metering improves forecasting of assets behaviour, offers better resolution and visibility of assets and enhances informed control of assets compared to boundary metering.

Analysis and Observations

In the FUSION trial, flexibility validation was performed exclusively using sub-meter data for all congestion points and participating aggregators. Some of the assets, such as CHPs and EVs, had an integrated sub-meter. Whereas for other residential assets the sub-meter was installed by the aggregators.

Based on aggregators' experience with sub-metering arrangements, both aggregators suggest that they prefer the use of sub-metering versus connection point meters in flexibility services:

- Sub-metering offers better resolution and visibility of asset behaviour
- Sub-metering allows for more informed control of assets

- Forecasting at asset sub-meter level is more straightforward because it excludes forecasting of other assets which might also sit behind the main meter. If sub-metering is used, then forecasting of flexibility also takes place at sub-meter level. When forecasting demand/ generation at asset sub-meter level, aggregators only have to take into account the flexible assets which is under aggregators' control. If MPAN is used, then aggregators would have to provide a forecast at MPAN level which includes assets that sits behind the meter and for which aggregators do now have visibility of.

- Access to MPAN data of residential assets is not possible to non- supplier aggregators.

The findings of the use of sub-metering arrangements in FUSION trial are discussed in detail in ITLR#2, section 4.5.

Next Steps

- ❑ Using sub-metering arrangements (asset level metering) is already possible in GB in ESO balancing services. It can be further explored in DSO services to understand how it can fit into existing baselining, forecasting and settlement processes.

4.2. Additional Learnings for the DSO

In addition to findings from the analysis of USEF innovative elements during trials, project FUSION has generated DSO-specific learnings which are either based on the analysis of either the UIE or other learnings objectives.

Learning 1: Flexibility providers value an end-to-end process with automation in areas such as settlement, information exchange on availability and dispatch instructions. They also value integration of all processes in one platform. [70]
The importance for the DSO is that simplified and standardised processes encourage participation, especially of smaller assets. Although this enabler is already recognised by industry, it is worth highlighting here, because it was one of aggregators' key messages throughout project FUSION, particularly during the final engagement sessions. For example, reporting availability manually or completing the settlement processes manually can add considerable costs and effort to aggregators, which can be a large barrier especially for smaller businesses or aggregators with small/residential assets.

Learnings 2: The effectiveness of non-firm assets bidding outside contractual windows or above contracted capacity is dependent on the contractual arrangements and payment structure. [71]
Bidding mechanisms outside the contractual windows or above the contracted capability allows for additional revenue which gives more revenue to uncontracted assets as they join the market.

70 Linked to USEF UIE MCM findings. ITLR#4, section 4.1.3

71 Linked to UIE free bids. ILTR#4, section 4.1.1.

This in turn, means more revenue opportunity for aggregators. As discussed in previous section (4.1.6), the mechanism itself is perceived attractive especially for non-firm and residential assets which have not joined the flexibility market before.

However, the attractiveness of such mechanism (e.g., free bids)[72] depends on the contractual arrangements and payment structure . While aggregators appreciated the mechanism as an extra revenue source, their focus in the trial was on fulfilling their obligations on availability. The non-delivery/non-availability of flexibility under availability contract penalises aggregators, and logically they are incentivised to solve this problem. On the other side, the financial incentive of free bids payments on utilisation was small to justify aggregators' engagement with the mechanism.

It should be however noted that such a mechanism does not solely apply to assets that have availability contracts with the DSO. It mostly applies to flexible assets that have no availability contract with the DSO, but they can still offer their flexibility only via a "free bids" mechanism. In FUSION trial, this concept was not tested (i.e., participation of assets with no availability contracts).

Learning 3: Shorter procurement timeframes[73] allow the DSO to order flexibility based on a more accurate forecast and increases reliability of flexibility. This must be balanced with need to give flexibility providers visibility over when flexibility might be required.[74]

In UIE Finding 1 (Section 4.1 of this report), we have thoroughly analysed the first leg of this Learning. Under this section we would like to highlight that the DSO should carefully consider when the market is ready to move to closer-to real time procurement and what is the most appropriate procurement timeframe.

Aggregators reported that ordering day ahead struck the best balance between ordering week-ahead or intraday and gives customers sufficient visibility of when their assets will be utilised but not restricting what they can do with them. This day-ahead notification is easier to sell to potential customers than shorter notification times between FlexOrders and delivery

When the DSO orders flexibility week-ahead, then aggregators have limited visibility of when their assets can be utilised. On the other side, when the DSO orders flexibility intraday, then aggregators have limited time to respond and adjust the demand/generation of their assets in order to activate the required flexibility.

In the future, when forecasting and monitoring capabilities of aggregators and flexibility providers are enhanced, closer to real-time procurement may also be feasible. Project FUSION has not analysed this opportunity further.

Learning 4: The DSO needs to over-procure flexibility to account for their own load forecast inaccuracy, aggregator baseline inaccuracy and reliability of delivery (which project FUSION has defined as DSO procurement cost drivers. Baseline accuracy has the largest impact on the additional volume of flexibility required by the DSO.
It is important to have a better understanding of how to split the risks between DSO and aggregator to ensure network reliability whilst lowering entry barriers for aggregators.

The trial showed that the different DSO cost drivers would have a significant impact on the volume of flexibility required by the DSO to ensure that the required flexibility is delivered.

72 For example, raising the free bids price cap in phase 2 had a positive effect in raising public interest (from aggregator's customers) on flexibility and provided a stronger incentive which encouraged participation.
73 Day-ahead and intraday versus BAU week-ahead timeframe
74 Linked to UIE MCM, ITLR#4, section 4.1.3

Project FUSION analysed the following DSO flexibility procurement cost drivers which influence the required volume of flexibility (either availability, utilisation or both):

1) DSO Load forecast accuracy: The load forecast is used by the DSO to determine the required volume of flexibility. Load forecasts include a certain inaccuracy. DSO forecast inaccuracy leads to an upper and lower bound of the load forecast resulting in more flex procurement than is required.
2) Baseline accuracy: A baseline approximates the energy consumption or generation by an aggregator if no flexibility is activated. It is used to determine the required volume of flexibility (both availability and utilisation). In practice, baseline methodologies include a certain inaccuracy. This inaccuracy leads to a bandwidth for service delivery and can lead to two scenarios
    a. The DSO carries the risk by factoring in the inaccuracy when it procures flexibility by procuring more than required
    b. Aggregators carry the risk and factor it in by overdelivering of what was ordered
3) Service delivery reliability: The final driver is that the service delivery by aggregators is not fully reliable. The DSO mitigates against this by either contracting with multiple aggregators or by over-procuring flexibility at additional cost. A service contract can include a minimum service level on performance and reliability; however, it is worth noting that the higher the reliability requested by the DSO, the higher the unit price of the service.

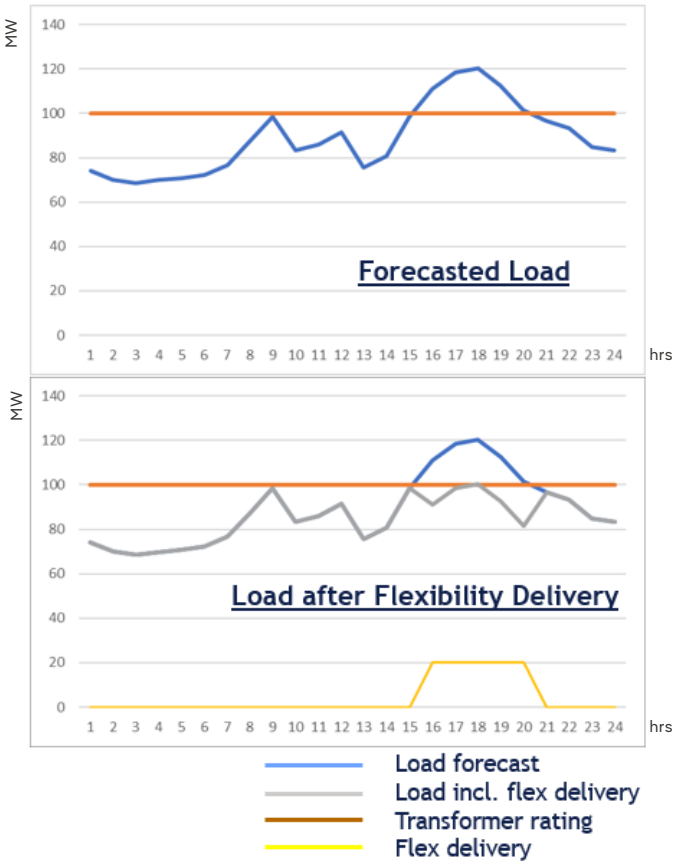
FUSION results showed that significant over-procurement of flexibility would be required across all congestion points to account for the different drivers: ranging from 61% to 463%[75] based on quantitative analysis which is presented in ITLR#4, section 4.1.4.2. The analysis has used trial data and compared the USEF-based flexibility market with an ideal scenario where the DSO flexibility procurement cost drivers (i.e., DSO Load forecast accuracy, baseline accuracy and service delivery reliability) achieve very high performance (i.e. perfect load forecast, perfect baseline methodolpgy and perfect service delivery). This theoretical counterfactual scenario has only been used for the purpose of the "DSO procurement drivers" analysis and has not been used in other learnings of project FUSION such as the CBA or the reliability assessment. [76]

75 Table 16 in ITLR#4, section 4.1.4

76During the analysis of FUSION trial, we have compared FUSION against other trials, or different coutnerfactual scenario. For example, we compared FUSION's reliability against the reliablity of other trials and Innovation projects. We compared the impact of day ahead procurement versus 4-days ahaed procurement on the DSO freocast accuracy and we compared different baselining methodologyes. In addtition, the CBA has used different assumptions and inputs in order to produce a coutnerfactual scenario. It should be clarified that the analysis of the DSO cost Procurement drivers has used an ideal theoretical scenario, which has not been used in the forementioned comparisosn.

In particular:

- the baseline accuracy has a large impact, for the FUSION trial as well as BAU, and therefore is an area that requires attention as the trial moves into the final stages. Improvements in baseline accuracy can reduce over-procurement by a range of 17% to 72% across feeders used in Project FUSION.
- The impact of the load forecast accuracy varies significantly across the different congestion points. DSO can procure closer to real-time or improve the forecasting methodologies. FUSION assessed the forecast accuracy in different time frames and found that there is moderate benefit in improving load forecast accuracy when ordering closer to real time. Additional flexibility required due to DSO load forecast accuracy levels is between 13% to 22% across FUSION feeders (although in one feeder the amount was 248% which was considered an outlier of the analysis).
- the service reliability had the least impact on the additional flexibility required. The flexibility required due to reliability of delivery levels was from 9% to 27% (although in one feeder the amount was 116% which was considered an outlier of the analysis).



All these elements introduce a layer of uncertainty that is then translated into a risk/cost, for the DSO and the aggregator. The risk for aggregator is linked to the reliability of the flexibility and the need to procure higher volumes, while the risk for the aggregator lies in baselining implications and accurate compensations.

Next steps: It is important to consider how best to split the risks of reliability of delivery (and baselining implications) between the DSO and aggregators to ensure network reliability whilst lowering entry barriers for aggregators. It is also important to understand how different measures would impact each stakeholder. For example, if a certain level of baseline accuracy is required, some flexible technologies might be excluded, leaving more expensive technologies incurring a higher cost for the DSO.

Non-firm assets (e.g. residential assets) and non-dispatchable generation could struggle with achieving very high baselining accuracy as they (and the aggregators) need to enhance their short-term monitoring and forecasting capabilities. On the other side, assets that have been traditionally participating in flexibility services (e.g., ESO services), like dispatchable generation and large industrial loads have more advanced baselining capabilities and accuracy restrictions would not be a barrier for participation.

Learning 5: Some USEF and FUSION commercial mechanisms were reported by aggregators as having been influential in securing customers participation, particularly from residential flexibility providers. [77]

During the trial, project FUSION observed that 80% of contracted flexible capacity came from residential customers contracting through an aggregator. Although there is not a causal link between FUSION and USEF features with this high numbers of residential participation it is worth highlighting some features that could have been influential.

USEF creates a more level playing field between residential assets and commercial flexibility assets:

- Day-ahead trading: Aggregators reported that ordering day ahead gave customers sufficient visibility of when their assets will be utilised but not restricted what they can do with them. This is particularly important for residential customers who are not used to flexibility markets, and they cannot commit to flexibility days or month in advance. Commercial assets (particularly larger commercial assets) have better visibility of their operations and can better plan for flexibility activation even prior to day ahead.

- It allows portfolio bidding, rather than bidding at asset level or static portfolio bidding, which means that the aggregators do not have to differentiate between firm and non-firm assets (which are typically residential assets). Aggregators use each asset based on their availability to provide flexibility when this is required. This is particularly important for residential assets, because it is easier for aggregator to include them in their portfolio. During FUSION trial, aggregators were able to switch flexible assets in and out of portfolios during the trial, which is not possible with the static portfolio bids.

- It does not require pre-qualification of assets, which also shows that USEF is that USEF does not see differentiate residential and commercial assets as it relies on portfolio bidding.

USEF and FUSION encourage non-firm participation in flexibility markets:

- USEF proposes standardisation of the interaction between aggregator and flexibility provider platforms for flexibility services. In addition, within the FUSION trial communication between aggregators and customers was also automated and standardised via APIs. Through this standardisation onboarding was smoother and streamlined at lower entry cost for both aggregators and end-consumers. If USEF/FUSION mechanisms are more widely adopted, it will reduce aggregator costs and effort for interacting with market platforms and end-customers and should lead to increased consumer participation.

- Free bids are a mechanism which provides access to non-firm capacity to participate in the market which is well suited to residential customers. Aggregators reported that the offer of Free Bids was attractive to residential customers at the time of onboarding.

- The automation offered by the Common Reference was reported by aggregators as an enabler to smoothly onboard non-firm and residential assets, which otherwise could lead to time consuming processes and could have potentially discouraged aggregated in developing large portfolios of small assets.

77 Section 4.2 in ITLR#2 and section 4.2.3 in ITLR#4.

- Inclusivity of nomination baselines: Some baselines are technology-agnostic and suitable for (almost) all technologies, whilst some other baselines may be applicable or accurate only for certain technologies, consumer types and portfolios of assets. Nomination baselines are considered highly inclusive as they allow flexibility provider to provide forecast of the generation/demand based on any calculation methodology which suits their flexible assets and taking into account all relevant and available data.

Our analysis has also shown that features such as USEF's FlexReservationUpdate, which allows the DSO to temporarily release the aggregator from their contractual availability obligations when flexibility is not needed, encourages participation.[70] Aggregators believe that a concept that allows the DSO to temporarily release the aggregator from the contractual availability obligations when flexibility is not needed by sending an update to aggregators (i.e. FlexReservationUpdates) bring significant value to flexibility markets, since it allows flexibility providers to:

- Avoid sending a false alarm to customers if they are not going to be activated (alarm is sent when the aggregator sends a FlexOffer to the DSO)
- Manage their portfolio and make assets available for other uses. During phase 2, aggregators did not use this feature and did not offer their flexibility in other markets, simply because they are not active in other markets yet. Nonetheless, in the future, they consider offering flexibility for e.g., to the new ESO DFS service and the BAU DSO flexibility services of SPEN.
- Adjust their bidding strategy. If there is value stacking with flexibility reserves, this may allow aggregators to adjust the bids to make them more competitive for the DSO.

Finally, it should be noted that FUSION deployed a targeted marketing campaign toward residential customers during the procurement process which could have also been influential for achieving high residential participation.

The DSO can consider which FUSION elements and commercial arrangements might contribute to increased residential participation (e.g. use of non-firm assets in flexibility services, free bids, standardisation of processes which facilitates easier integration of residential assets, inclusivity of nomination baselines, USEF's FlexReservationUpdate).

At this stage, it is worth acknowledging that the market has evolved since project FUSION started; flexibility markets and familiarisation of aggregators and flexibility providers with DSO flexibility markets have improved since the beginning of FUSION. In addition, since 2022, GB DSOs and particularly SPEN have reported increased volumes of contracted residential flexibility. This is an evolving market, and it suggests that years of effort to increase penetration of residential flexibility in GB might be starting to bear fruit.

Learning 6: DSO's should collaborate closely with aggregators on baselining for better, fairer and more efficient flexibility markets

Project FUSION collaborated very closely with NIC Project Transition. Both projects experienced challenges with receiving accurate baselines from flexibility providers. Uncertainty and error in baselining are unavoidable and it is not trivial to balance accuracy with other market requirements for baselining methods such as simplicity and inclusivity.

A joint workshop led by SPEN's FUSION and SSEN's Transition project developed several industry recommendations.[78]

78 https://ssen-transition.com/wp-content/uploads/2023/04/TRANSITION-FUSION-Baselining-recommendations-April-2023.pdf

Primarily, it was recommended that DSO's and flexibility providers need to work together to understand the risks associated with service validation and settlement, and balance risks between the flexibility buyer and seller. One example of this is that the settlement structure should have cap and floor limits reflective of the accuracy of baselining methods to balance the reward to the flexibility providers and to motivate participation whilst discouraging under-delivery. The DSO should also consider helping to develop industry-wide guidance outlining standards for application of baselining methods, settlement mechanisms and data interfaces.

Learning 7: Learnings and opportunities from international experience and collaboration can enable more efficient operation of flexibility markets and encourages participation

One element that was partially explored in FUSION was the benefit of using flexibility mechanisms that can be applied in other countries and by different markets.

For example, USEF is also used in Dutch DSO markets. This shared experience:

1) gives the opportunity to share learnings and best practices. For example, project FUSION continuously engaged with the USEF Foundation (called SHAPESHIFTER for the last 2 years). This interaction led to changes to the USEF framework but also to efficiencies during the project. During the testing processes, a third-party supplier from the Netherlands which was experienced with USEF supported the development of DSO stubs which were used for testing.
2) enables aggregators to use other services and participate in various markets where they can use the same IT systems and communication protocols.

GB DSOs should seek for international collaboration and shared learnings opportunities during the development of flexibility markets, as they can share best practices to increase effectiveness and efficiencies of the market. In addition, international collaboration could potentially give aggregators the option to use other services and participate in various markets where they can use the same IT systems and communication protocol, which in turn increases their revenues streams and encourages aggregators' participation in flexibility markets.

4.3. Additional Learnings for Aggregators

Project FUSION has used the analysis of USEF innovative elements and trial outcomes to generate aggregator-specific learnings which are either based on the analysis of the UIE or other learnings objectives.

Learning 1: Aggregators should have the capability to process large amounts of data in order to effectively and efficiently participate in flexibility services.

During the trial, aggregators encountered several challenges related to data storage and processing. For example, a specific aggregator was unable to supply meter data for certain non-event[79] days, which would have been beneficial in evaluating their baseline quality.

Aggregators must have the capability to process large amounts of data to enable communication with the DSO. This is particularly relevant to those aggregators with large numbers of small customers, required for validation and settlement, and to allow the DSO to verify the quality of the baseline.

79 i.e.; those days during which there was no flexibility ordered

General IT expertise is crucial to performing the role of aggregator effectively. Aggregators must ensure they have all the necessary capabilities to fulfil IT requirements, before starting to operate in local flexibility markets. These capabilities will mitigate the risk of errors and the reduce the need to carry out time-consuming processes.

Learning 2: Aggregators over-delivered flexibility volumes during the FUSION trial

Aggregators delivered on average 160% more flexibility than ordered. Feedback during interviews showed that the primary driver for this was to overcome inaccuracies in defining an accurate baseline and to ensure they meet ordered flexibility volumes and satisfy contractual arrangements (thereby avoiding penalties).[80]

From a network management perspective, over-delivery is not always desirable; one of the risks of over-delivery of flexibility is that it becomes more difficult to counteract the action to neutralize the effect on the system balance (the so-called redispatch); redispatch is a necessary part of any activation of flexibility as part of a constraint management service that was not being examined in this trial.

By avoiding strategies to over-deliver, for instance by improving the baseline accuracy and the reliability of their control systems, aggregators had the potential to earn more per unit of flexibility as they reduce the amount of flexibility which they deliver and for which they are not paid.

Learning 3: Aggregators must monitor the accuracy of their baseline and update their methodology if required

Accurate baselines ensure that aggregators are fairly rewarded for the flexibility they deliver and ensure that it also has the desired impact on the network. FUSION analysis of trial data showed that although aggregator baselines indicated the poor quality of aggregator baselines. The accuracy of baselining methodologies is discussed in UIE Finding 4 and in detail in ITLR#4 section 4.1.2.

A collaboration between Project FUSION and Project TRANSITION explored ways to improve aggregator baseline quality. [81] These recommendations centred around on-going monitoring and communication between DSOs and aggregators:

1. Aggregators should collaborate closely with the DSO to monitor the quality of their baseline and implement changes to their methodologies if required
2. Standardisation of the metrics for evaluation of baselining quality (including acceptable ranges) and the reliability of flexibility delivery
3. Consideration of Same – Day Adjustment in baselining

Learning 4: DSOs will only consider relying on 'free bids if there is sufficient market liquidity and mature markets.[82]

Free bids remove the risk to aggregators being locked into long term commitments, allowing end consumers to bid in and provide flexibility whenever their asset is ready. Analysis showed

80 ITLR#4, Section 3.3

81https://ssen-transition.com/wp-content/uploads/2023/04/TRANSITION-FUSION-Baselining-recommendations-April-2023.pdf
82 Linked to UIE free bids. ITLR#4, section 4.1.1.

that free bids in the trial had a similar reliability to normal bids across the majority congestion points.[83]

Despite this, relying on non-firm mechanisms outside contractual arrangements, such as free bids, and moving away from availability contracts, is still considered by DSOs as a risk. SP Energy Networks stated that it would consider exploring moving into a system that was more reliant on free bids as long as there was sufficient market liquidity to make that approach statistically reliable, which is highly dependent on the location for congestion management services.

Learning 5: Aggregators faced challenges in recruiting new flexible assets, driven by technical limitations but also market arrangements.

Aggregators experienced challenges in bringing on additional flexible assets. They noted technical challenges when installing monitoring and control equipment on new assets and dealing with businesses with multiple subcontractors, which increased the lead time of new connections from what was initially envisaged.

Aggregators faced the biggest challenges with domestic assets as these assets are more difficult to control and forecast. These considerations should be factored in when agreeing on their contracted availability volume. Aggregators must ensure that they do not overestimate how much flexibility they can secure in their portfolio if required to state their flexible capacity significantly in advance as in FUSION.

It is worth mentioning here that the challenge for aggregators was to recruit new assets that have not participated in flexibility markets before which is key to unlocking high flexibility volumes. Assets that have already participated in flexibility markets for many years (including ESO markets) are typically more willing to participate in DSO flexibility markets because they are more familiar with the processes and in most cases they have already installed monitoring and control equipment. Finally, aggregators commented on how the procurement timelines have impacted their ability to recruit additional customers. Declaring availability volume more than 6 months ahead was considered less attractive, especially by non-firm assets but also by commercial assets which did not have visibility of their operations 6 months in advance. In addition, contracting far in advance restricts stacking with other markets (e.g., NGESO's Demand Flexibility Service and SP Energy Networks' BAU flexible services).

4.4. Improvement to Network Performance

Improvement to network performance was assessed as part of the Cost Benefit Analysis[84] that was prepared by an independent team from ICL and is discussed in detail in Section 8.3. As a highlight of the local network benefits based on the CBA potential savings from USEF-based flexibility that could be achieved on one of the congested feeders that was studied are estimated at about £695-728, or 13% above the benefits of the BAU-based flexibility.

Figure 22a shows the CML when considering flexibility provision for the USEF-based scenario and a comparison between BAU and USEF scenarios at one feeder, where thermal-driven CML is reduced from the reference case (shown in Figure 5a) by 509 and 543 minutes per customer, respectively. An additional 34-minute CML reduction per customer is observed in the USEF

83 Figure 16 in ITLR#4, section 4.1.1.
84 https://www.spenergynetworks.co.uk/userfiles/file/FUSION_CBA_report_Feb_2023.pdf. Please check section 3 of the CBA report for more details in the Network Local Benefits.

scenario relative to BAU, as shown in Figure 8b. No reduction is observed in feeders 18615 and 19324 as no thermal-driven CML is observed in these feeders in the counterfactual (no-flexibility) case.

Figure 21a shows the Expected Energy Not Supplied (EENS) quantified for the USEF-based flexibility scenario. Similarly, to the CML results, thermal-driven EENS is reduced by 26,759 and 28,549 kWh/for feeder 18614 in BAU and USEF scenarios, respectively. USEF therefore provides an additional 1,790 kWh/a reduction in EENS compared to BAU performance (Figure 21b).

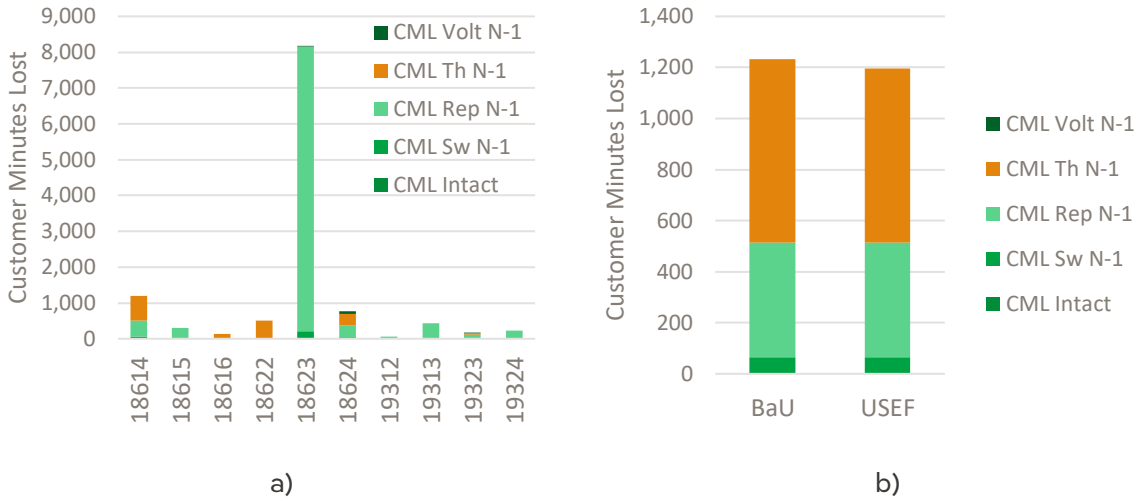


Figure 20. CML for a) USEF-based flexibility and b) difference between BaU- and USEF-based flexibility scenarios for feeder 18614 (the only feeder where difference is observed).

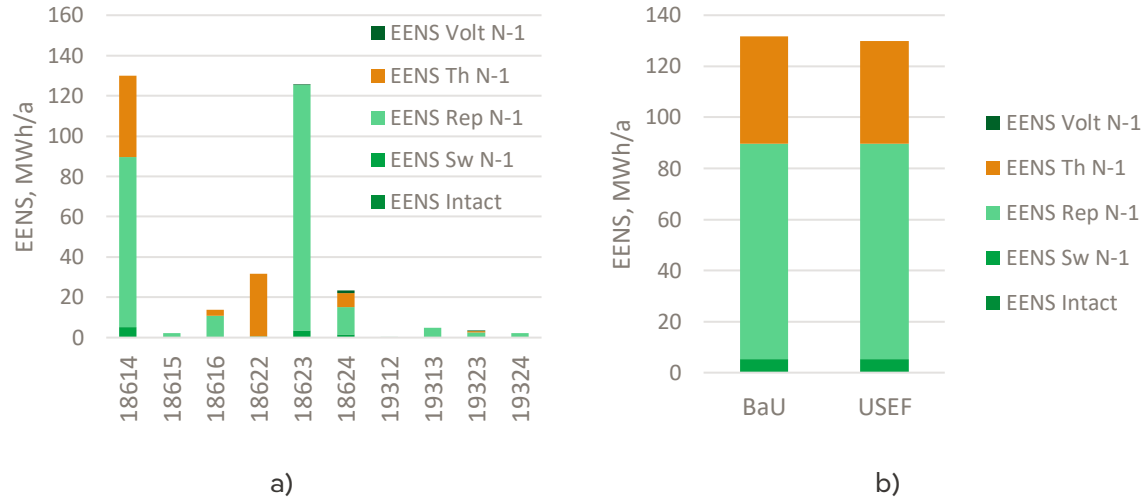


Figure 21. EENS for a) USEF-based flexibility and b) difference between BaU- and USEF-based flexibility scenarios for feeder 18614 (the only feeder where difference is observed).

In addition to the benefits captured in the CBA analysis referred to above, it is worth reporting a real-life provision of standby capacity to help accommodate peak loads during the 2022 St Andrews Open, which is a major sporting event within a congested area of the network. In preparation for the event and in anticipation of increased loading on that asset (based on previous incidents of the event), the FUSION market secured local flexibility availability that could be dispatched within 15 minutes to reduce loading on the asset if necessary. During the

event one of the flexible assets was dispatched (not out of necessity, but for learning purposes only) and reduced its loading corroborating the studies wider findings[85] which demonstrate the efficacy of the FUSION flexibility market to realise a fast and reliable reduction in local loading when required.[86]

In addition, FUSION provided 500kW of standby capacity to support the DNO in managing local network needs during a planned outage of a transformer at St. Andrews Primary substation (Apr 2022).

Finally, the FUSION trial's demonstration of the consistent reliability of ordered flexibility services was one of the several factors which contributed to SPEN's updated connection strategy to accelerate new connections (in April 2023) in East Fife area in light of the following factors:

1. Guardbridge primary reinforcement anticipated to be commissioned by the end of 2025 which will bring relief to the east fife congestion points alleviated by flexibility in FUSION.

2. Flexibility has proven itself to be able to provide reliable support to manage peaks in the meantime. Although FUSION trial has now ended, project FUSION has created legacy in flexibility markets. For example, the hardware, software, communication systems and aggregators are all still available in the area, so SPEN could extend contracts at short notice if SPEN perceives the need to do so.

4.5. USEF TRL - Change Resulting from the Trial

As per the initial submission, the Technology Readiness Level (TRL) of USEF Framework and the UFTP was 6. The TRL was already high as USEF Framework had been applied in previous trials and project in the Netherlands prior to its implementation in GB. Please note that TRL 6 refers to "technology demonstrated in relevant environment".

At the end of the trial the TRL of USEF Framework and the UFTP has increased to 8 – "system complete and qualified". The key steps and associated changes that occurred during the project and have led to increase in the Technology Readiness Level are:

1) GB Implementation Plan: The first stages of project FUSION indicated that USEF is largely applicable to GB flexibility landscape and that it fits GB market.

2) **Flexibility Value Chain:** Project FUSION conducted a due diligence to understand USEF fit in GB. Based on the outcomes of the due diligence and the consultation the USEF Flexibility Value Chain was expanded to include post-fault products and restoration products as per GB DSO standards.

3) **UFTP changes:** The UFTP was enhanced following changing requests submitted in the project FUSION context (by Gridimp) to the SHAPESHIFTER TSC on 1) metering 2) service type and 3) allowing multiple congestion points per connection. These changes were approved and are now part of the UFTP specification 3.0.1.

4) **IT Development:** SP Energy Networks explored the possibility of engaging with another aggregator to trial a demand turn-up service. Although USEF supports this concept, the

85 Over the course of the 18-month trial, over 500 flexibility dispatches were realized, with an observed reliability of delivery of 80%,
86 Project Progress Report 4, Appendix C

FFP was not designed to place orders for demand turn-up, nonetheless, the test was conducted and demonstrated that it could be used to do so. SP Energy Networks trialled this use case by using a hypothetical congestion point to which a simulated aggregator with a hypothetical DER portfolio was allocated. The role of the simulated aggregator was fulfilled by SP Energy Networks using the AGR-simulator (plug-in) developed by OrangeNXT. The use of the plug-in demonstrated that non- USEF compliant aggregators to are able participate in the FUSION flexibility market without having to implement USEF within their own platforms or any relevant IT development.

4.6. How Method(s) Could Be Applied to Other Licensees

In order for USEF Framework and UFTP to be applied by other licensees, project FUSION has produced a number of documents that provide detailed guidance and helpful information and are presented in Table 4. These documents in conjunction with USEF publications should provide sufficient information to set the basis of USEF implementation by other DNOs and market participants (i.e., aggregators). In addition, Section 0 (

Project Replication) of this report summarises the main components to support future replication of the project.

Table 4: FUSION documents to support further USEF Implementation

Document	Context
Flexibility Services Agreement Template	Flexibility Services Agreement, tailored to FUSION DSO Services.
FUSION USEF Implementation Plan	This document describes the deployment of innovative elements from the USEF Framework in the FUSION Flexibility market. It also provides an overview of the USEF processes, information exchange and IT architecture that a DNO and flexibility providers would need to implement for a FUSION-like trial.
Communication protocols between market participants	This document sets out the minimum requirements for implementing the USEF Flex Trading Protocol (UFTP). The UFTP forms the basis for the communication protocol to be adopted in the FUSION trial. The document used by GB flexibility providers as a guide to the process and technical requirements to participate in the FUSION trial.
Specification of communication and procurement platform	This document sets out the roles and functional requirements for the FUSION Flexibility Platform (FFP) that delivered the USEF Trial for FUSION. This
Interim Trial Learnings Report #1 (Oct 2021)	This document describes the procurement processes, the testing and implementation that took place so that the trial went live.
UFTP Specification Library	This is a Shapeshifter library is a library written in Java that implements the Shapeshifter UFTP (USEF Flex Trading Protocol) protocol.

The approach to implement USEF would have to be similar to Project FUSION with regard to activities related to the development of DSO Flexibility Platform (FFP in FUSION, developed in WP4), the implementation of UFTP by aggregators (develop in WP4) and implementation of processes related to trading flexibility through a USEF-based flexibility markets (relevant to WP5 Deployment of a live trial). For example, it is expected that every DSO who wants to implement UFTP, they would need to develop a DSO FFP according to specifications defined by FUSION. [87] In addition, WP1 (stakeholder forum) was only relevant for project FUSION which was an innovation project. As a results, it is not expected that stakeholder engagement would be critical for the implementation of FUSION by another DNO. WP2 was only relevant to FUSION when deciding about the location of the trial and recruiting customers and aggregators. Another DSO may apply a different approach in recruiting (e.g., through PICLO) and may have a different approach in deciding where to create a USEF-based flexibility market. WP3 (planning for USEF implementation) was only relevant to project FUSION and does not have to be repeated because the USEF implementation plan is already in place. Other DNOs can use outputs of WP3 to understand the high-level implementation of certain USEF features – the detailed implementation and guidance would be provided from the outputs of FUSION's WP4.

87 https://www.spenergynetworks.co.uk/userfiles/file/D4.1_specification_of_communication_and_procurement_platform.pdf

5. Project Performance

This section will describe how project FUSION performed against its aims & objectives and the key learnings that were generated by fulfilling these objectives.

5.1. Project Aim

Project FUSION's aim as per the initial submission to Ofgem was to: *"…demonstrate the feasibility of geographically local commoditised flexibility, accessible through a universal, standardised market-based framework – The Universal Smart Energy Framework (USEF), to address distribution network congestion issues, and complement national balancing requirements within the existing regulatory framework."*

This aim was successfully achieved through the establishing and operating of a live flexibility market based on USEF, between September 2021 and April 2023.

5.2. Project Submission Objectives

The initial submission to Ofgem enumerated five specific objectives that the project should address. Based on the learnings that were summarised in section 4, alongside all the data analysis of the 2-year FUSION trial, project FUSION met and addressed the submission objectives. This section provides a review of the project's performance in addressing their goals.[88]

Table 5: Project submission objective successes and outcomes

1. Evaluate the feasibility, costs, and benefits of implementing a common flexibility market framework based on the open USEF model to manage local distribution network constraints and support wider national network balancing requirements.
Meeting the Objective
✓This objective and its learning objectives are primarily met with the Cost Benefit Analysis of USEF-based flexibility market assessing local and wider benefits. The CBA was produced by an independent team from ICL based on quantitative analysis using trial's data. ✓Implemented and successfully operated the first GB fully USEF compliant flexibility market realising +500 dispatches ✓As part of the analysis that was required to perform the CBA, project FUSION team tested a number of USEF innovative elements. The team performed data and statistical analysis using data from the trial implementation (see Interim Trial Learnings Reports ITLR#1, ITLR#2, ITLR#3 and ITLR#4); ✓Assessed the implementation costs of USEF for aggregators and the DSO. [89] The Cost Benefit Analysis report which is the key output to meet this objective can be found in project FUSION website.
Outcomes
Fusion implemented and successfully operated the first GB fully USEF compliant flexibility market realising +500 dispatches.

88 ofgem.gov.uk/sites/default/files/docs/2017/11/fusion_-_fsp_redacted_29_11_2017.pdf. Section 2.1
89 Quantification of market participant costs for implementing USEF (spenergynetworks.co.uk)

Local Benefits from the trial, only based on the 2 years trial data:

- USEF-enablement cost was estimated at £147k, which is incurred by both aggregators and the DNO (£87k for the DSO and £30k per Aggregator).

- USEF-market total costs (including enablement costs and flexibility payments) were estimated at £2m.

- Potential savings from USEF-based flexibility resulting from both network upgrades and CML reduction: 13% over BAU (at about £695-728). This observation is only derived by analysis on one feeder. In two out of three HV feeders where FUSION trial flexibility assets are connected there was no network congestion observed so analysis was not feasible.

- When the total observed benefits of flexibility are compared to USEF-enablement costs and payments, the total cost significantly exceeds the benefits, which is expected given that FUSION was an 18-month trial under an innovation project and that flexibility providers had to be incentivised to participate in such a short-lived market[90].

- The FUSION concepts benefits in network upgrade deferral and customer minutes lost reduction wis expected to increase in the future due to higher network loading and unlocking of additional sources of flexibility compared to BAU-based flexibility.

Cost Benefits Analysis – GB wide benefits of GB implementation of USEF (timeframe up to 2050)

- Net system benefits of USEF-based flexibility arrangement ranging from £216m/yr in the System Transformation (ST) scenario in 2035 to £654m/yr in the Consumer Transformation (CT) scenario in 2050.[91] These benefits are measured against a BAU flexibility market case study where the bulk of distributed flexible resources remains underutilized due to lack of a suitable market framework. This assumption should be treated with caution especially as we already see that existing DSO markets having started recruiting residential assets.

- The present value (PV) of FUSION deployment cost £3.2bn in the ST scenario and £11.5bn in the CT scenario.

- The PV of corresponding whole-system benefits: range between £6.2bn and £17.3bn across the two system scenarios.

- Positive NPV of net system benefits of FUSION totalling £2.9bn and £5.8bn for the ST and CT scenarios, respectively.

- FUSION would provide positive a net system benefit if its deployment cost is lower than £31-51/MWh of flexible energy demand, or lower than £32-42 per kW of flexible capacity. It should be highlighted that the CBA did not take into account the GB wider deployment cost of FUSION. The omission of this cost was agreed on the basis that any estimation of GB deployment cost would entail high-level caveats and large assumptions that could distort the analysis and the learnings. Instead the analysis sought to establish the upper limit of that cost, beneath which it would be reasonably viable for GB indsutry to widely deploy FUSION. For reference, the deployment activities would require at least the deployment of the FFP platform across all DSOs and participating aggregators, as well as enablement costs in order for the customers to participate in FUSION flexibility market.

- This suggests a positive business case for FUSION from the whole-system perspective due to its gross benefits exceeding the implementation and enablement cost.

90 Availability payments have to cover all other costs - costs of participation and cost of implementation, contractual arrangements and negotiations etc.
91 NG ESO Future Energy Senarios 2022

The outcomes of the CBA are discussed in detail in section 8.

2. Investigate a range of commercial mechanisms to encourage flexibility from energy consumers' use of multi-vector electrical applications in satisfying overall energy use.

Meeting the objective

✓ Explored how USEF encourages aggregator participation in flexibility markets; and Flexible asset owner participation in the market through an aggregator;

✓ Procured contracts with two aggregators with diverse portfolios of assets. These assets included: CHPs, HVAC, EVs, heat pumps + water heater, battery + solar, and other DSR;

✓ Deployed a targeted campaign towards residential customers;

✓ Procured day-ahead flexibility and gave aggregators different notice times between ordering flexibility and delivery;

✓ Conducted regular interviews with the aggregators in order to receive feedback upon the effectiveness of commercial arrangements;

✓ Applied and trialled the impact of USEF's Market Co-ordination Mechanism (MCM) and of different market procurement timelines to facilitate access to the markets from a diverse portfolio; and

✓ Assessed the effectiveness USEF-innovative elements including free bids to facilitate flexibility from multi-vector electrical equipment and particularly from residential assets.

Full assessment of this objective is included in ITLR#3, section 4.8[92].

Outcomes

FUSION shows that the following mechanisms encourage customer participation:

- Standardisation of processes and automation under USEF and FUSION processes facilitate onboarding of new assets and particularly they enable aggregators to build large portfolios of small assets.

- Aggregators were able to switch flexible assets in and out of portfolios during the trial, which is not possible with the static portfolio bids.

- Aggregators reported that building their platform to support the FUSION trading structure prepared them for accessing other markets such as the balancing mechanism.

- Aggregators reported that the offer of Free Bids was attractive to residential customers when onboarding new customers, as it provides access for non-firm capacity to participate in the market which is well suited to residential customers. Despite its attractiveness to new assets, the current market and payment structures are not mature enough yet to fully leverage this mechanism (please read UIE Finding 3 in section 4.1 and Learning for the DSO 3 in section 4.2 for the full analysis of this point). By fully leveraging the mechanism we imply to 1) use the mechanism regularly, 2) use it for assets that do not have any contractual arrangement with the DSO 3) offer bid prices that are attractive for both the DSO and the aggregator when there is market liquidity.

- A refined approach to balancing utilisation and availability payments could make it easier to recruit new assets. One option for achieving this is to increase the utilisation payments in relation to availability, which would reward and encourage domestic customers who have a lower flexible capacity but could earn comparatively more through utilisation. This is also applicable to assets like operational plant,

92 https://www.spenergynetworks.co.uk/userfiles/file/Interim%20Trial%20learnings%20Report_Dec%202022.pdf

generation or storage assets behind-the-meter which are not installed for the primary purpose of making money through providing services to the grid or energy market, and they would be encouraged by incentivising utilisation payments, according to aggregators' feedback. It is also noticed that for existing assets which have been well established in providing capacity, reward of availability is still important. There is need for balance between availability and utilisation payments taking into account; 1) the DNO services requirements and needs and also 2) ultimate objective of recruiting more assets and creating liquid DSO markets.

- Notification time between FlexOrder and delivery is important to customers. Aggregators reported that ordering day ahead struck the best balance giving customers visibility of when their assets will be utilised but not restricting what they can do with them. Although this conflicts with the ambition of DSO to move closer to real-time, it should be noted that the markets are still at primary levels of development and monitoring capabilities of customers need further advancement, so that they can respond to changes in their demand/generation profile in short notice and without affecting their overall operating processes and activities.

- The inclusivity of the baseline methodology is seen as another factor that enhances the ability to connect a more diverse range of new assets. The benefits of a nomination baseline over a prescriptive baseline methodology are that nomination baselines allow different approaches to be used for different asset types. This is seen as something that can encourage participation from a wider range of technology types On contrary, when considering the inclusivity of historical baselines, achieving a high accuracy may be challenging for assets with an injection/offtake profile that does not follow a systematic pattern depending on the type and hour of the day.

Barriers of FUSION commercial arrangements to attracting more flexibility:

- The trial required aggregators to commit to availability contracts six months ahead of delivery, which created challenges in bringing on new customers due to uncertainty in revenue, penalties (in form on withholding revenue), sub-optimised flexibility use as well as redundant flexible capacity. In general, long term availability commitment poses a risk to aggregators in achieving their availability payment. The availability contracts six months ahead of delivery is not a USEF requirement, but a DSO product requirement. Although USEF is compatible with availability payments, it would also be entirely compatible with their omission, as USEF features focus more on rewarding utilisation.

- Domestic customers are the most difficult to control and forecast; although, this would be helped through automation and scale. Although this is a challenge for most of the customers, the barrier is more prominent for domestic customers who have not had similar experience in controlling their assets and are less familiar with flexibility markets. In terms of forecasting demand, domestic demand is in general more variable than commercial and industrial demand loads, which follow a pattern based on the operation of the business.

- Aggregators representing commercial customers faced challenges with interfacing with their client's internal IT systems and in dealing with multiple sub-contractors to carry out works which increased the lead time for new connections.

- Privacy and GDPR considerations were also seen as a potential barrier to the type of data that needs to be shared by customers in order for them to participate in the trial. Aggregators felt that sharing data at portfolio level is preferred as it enabled them to tell their customers that their data would not be shared externally.

3. Explore the potential for localised demand-side flexibility utilisation to accelerate new demand connections to the network that otherwise would require traditional reinforcement.

Meeting the Objective

In meeting this objective and the learning questions (presented in section 3.2.2), project FUSION:

✓ Investigated the additional peak demand that could be accommodated following implementation of a functioning USEF flexibility market as part of the updated CBA.[93]

✓ Based on quantitative data and actual annual load profiles, performed a network analysis to determine the achievable reduction in peak demand and the resulting improvements in network reliability parameters, including customer interruptions (CI), customer minutes lost (CML) and Expected Energy not Supplied (EENS). [94]

✓ Assessed the reliability of delivered flexibility based on trial's data

✓ Engaged with SP Energy Networks Planning team to understand how project FUSION outcomes are perceived and how they can impact their connections strategy and planning processes.

Outcomes

- Project FUSION achieved a real-life provision of standby capacity to help accommodate peak loads during the 2022 St Andrews Open, which is a major sporting event within a congested area of the network. In preparation for the event and in anticipation of increased loading on that asset (based on previous incidents of the event), the FUSION market secured local flexibility availability that could be dispatched within 15 minutes to reduce loading on the asset if necessary. During the event one of the flexible assets was dispatched (not out of necessity, but for learning purposes only) and reduced its loading, illustrating the efficacy of the FUSION flexibility market to realise a fast and reliable reduction in local loading when required.

- FUSION successfully instructed the delivery of flexibility to alleviate simulated constraints on the local network, situation not yet achieved by some DNOs. The trial results show that aggregators have achieved reliability of 80% or above at all congestion points except for Gridimp at St Andrews. This high reliability provides DSO with confident that flexibility services can be used 1. Manage network demand for pre-planned network events and 2. Reduce demand anxiety amongst network designers and operators.

- As a result, SPEN's District Planning team reported that they were pleased with the outcome of the FUSION trial in that it successfully demonstrated the efficacy of USEF-compliant local flex markets to reliably respond to DSO requests for localised capacity. The outcomes of the FUSION trial and the high reliability of flexibility was one of several factors which contributed to updated connections strategy for SPEN to accelerate new connections.Analysis of one congested feeder demonstrated that it could accommodate a 1.8% increase in demand due to USEF-based flexibility compared to no flexibility which is 0.2% % more than a BAU-based market. This corresponds to about 69 kW of demand increase. Note that this result is specific to that feeder and will vary based on the level of loading.

4. Through a live trial, gain an understanding of the potential use and value of flexibility within geographically local regions to further enhance efficient DNO network management.

Meeting the Objective

✓ Created and operated a flexibility market in an area that previously did not have one;

✓ Trialled and assessed USEF innovative elements which could benefit DNO network management;

✓ Explored how flexibility services at multiple congestion points provides support to common network (both 11kV and 33Kv);

93 https://www.spenergynetworks.co.uk/userfiles/file/FUSION_CBA_report_Feb_2023.pdf, Section 3.5.1
94 https://www.spenergynetworks.co.uk/userfiles/file/FUSION_CBA_report_Feb_2023.pdf, Section 3.5

✓ Explored how local flexibility can benefit all parts of the network (i.e., secondary, primary BSP, GSP and Tx system);

✓ Assessed the reliability of delivered flexibility based on trial's data.

Outcomes

- Local flexibility can deliver the range of flexibility services which are available to regional (and national) markets. The flexibility services that were delivered during FUSION by the aggregators using their asset portfolio are the same services that are delivered by BAU to reduce or remove constraints on a local or regional basis. In addition, one of the FUSION aggregators was also registered to deliver the new ESO Dynamic Flexibility Service, however they chose to participate in FUSION services only as there was a commercial incentive

- Local flexibility can provide suitable flexibility to all parts of the network - i.e., secondary primary, BSP (England), GSP and Transmission System. This means that flexibility can be delivered at one voltage level to meet an instruction for a flexibility service (DSO and / or ESO) at a higher voltage level; however:

    - the level of flexibility delivered may not always be detected by network monitoring equipment; and

    - the amount of flexibility that can ultimately be leveraged at the higher-voltage constraint is influenced by the associated electrical losses.

- The delivery of flexibility services at two local boundaries can provide an additive or complimentary flexibility support to the common network (i.e., two substations). More particularly, increasing the flexibility on one of the St Andrews 11kV feeders would not benefit any other St Andrews 11kV feeder but would reduce the loading of St Andrews primary substation by the same amount.

5. Through a live trial, demonstrate the proof of concept, and evidence the business case, of commoditised flexibility (locally and for GB) through a USEF-based flexibility market.

Meeting the objective

✓ FUSION conducted a due diligence of the commercial, regulatory and policy landscape in GB to accommodate USEF;

✓ Implemented changes to USEF Framework which were required for its adoption by the GB energy market;

✓ Successfully demonstrated the live operation of a USEF market in GB, including the testing of 6 x USEF innovative elements: D- programmes, Free Bids, Sub-metering arrangements, Baseline design/ nomination baseline, USEF Market Coordination Mechanism, USEF flexibility Trading Protocol (UFTP);

✓ Performed qualitative assessment of stakeholders' experience with USEF-based FUSION trial and quantitative analysis of trial statistics and data;

✓ Ongoing collaboration and engagement with the USEF Foundation.

Full assessment of this objective is included in ITLR#4, section 4.1.6.

Learnings

The evidence of the business case of a commoditised flexibility through a USEF-based flexibility markets has been addressed in the first objective of project FUSION (1).

Changes to USEF Framework: The FUSION trial has demonstrated that USEF framework is largely applicable to the GB DSO flexibility services. Following FUSION's work USEF went through the following modifications:

1. The USEF flexibility value chain was extended to include GB's dynamic (i.e., post fault) products;
2. The USEF flexibility value chain was extended to include GB's secure and sustain (i.e., pre-fault) products;
3. The USEF roles accommodated additional roles or responsibilities which are found in GB's arrangements;

The UFTP was enhanced following changing requests summited in the project FUSION context (by Gridimp) to the SHAPESHIFTER TSC on 1) metering 2) service type and 3) allowing multiple congestion points per connection. These changes were approved and are now part of the UFTP specification 3.0.1.

Project FUSION has collaborated in making modifications to increase the compatibility and identified two different areas that could be considered in the future to improve the suitability of USEF with the DSO standardised products.[95]

Effectiveness of USEF innovative elements: The effectiveness of USEF innovative elements highly depends on:
1. IT AGR capabilities: Aggregators did not fully engage with more advanced elements of USEF because their priorities focussed on implementing basic capabilities for flexibility trading, such baseline accuracy, asset performance/forecast, real time monitoring.

2. maturity of the market: The benefits of some USEF innovative elements could not be fully exploited as the markets need to be more advanced. For example, the benefits of sub-metering arrangements versus MPAN metering were not assessed in the trial due to issues with MPAN data access (see UIE Finding 4 in section 4.1. In addition, the full potential of free bids was not explored during the trial as discussed in UIE Finding 6 in section 4.1 and in Learning 3 of section 4.2.

3. local network characteristics: the high predictability of the flexible load demand and generation, driven by low intake of intermittent renewables, will lead to less benefit resulting from short term procurement for the DSO. FUSION elements such as D-programmes did not provide massive improvements in DSO forecast accuracy because the load demand is still predictable. In the future where we have more residential flexibility and more intermittent renewables, the benefits of short-term procurement for DSO forecast will be more visible.

USEF's contribution in commoditization of a range of technologies:

The trial has demonstrated the commoditization of all technologies which took part in the trial and that USEF creates a more level playing field for non-deterministic flexibility:

1. This is evidenced by the variety of assets that have participated in the FUSION trial
2. The USEF framework is technology-neutral by design. The aggregators do not need to inform the DSO on the technology (or technologies) behind their portfolio bid

95 Dynamic service: although FUSION trialled and proved that USEF could support the dynamic service, the process could be further optimised. The main issue is that the DSO needs to send FlexRequests in advance, for a certain capacity and duration, which means that there is little room for flexibility of response once a fault occurs. For example, if a fault occurs, the DSO will not know what the duration of the fault will be, but it would need to send a FlexOrder to an aggregator with a determined activation length. Consequently, this could incur in the activation being overly long (which implies more costs). To tackle this, USEF could consider adding a mechanism to stop a FlexOrder.

Demand turn-up: The USEF congestion management process is not designed to cover the demand turn-up service. By doing certain adjustments in the way the FFP was used, the DSO could dispatch the service, however, it was evident that process does not fully accommodate this (and it could not be automated). This gap would be considered outside the USEF scope.

throughout the flexibility trading mechanism. The DSO would select offers based on price and technical characteristics (power, start time, end time).

Moreover, aggregators have indicated that the USEF framework and FUSION arrangements have been influential in securing more residential flexibility -although there has not been a causal link between USEF arrangements and high residential participation. This outcome is discussed in detail in section 4.2 – Learning 5. In summary:

- USEF creates a more level playing field between residential assets and commercial flexibility assets using features such as day-ahead trading, portfolio bidding and the non-requirement for prequalification of assets.
- USEF and FUSION encourage non-firm participation in flexibility markets via the standardisation and automation of flexibility trading, the use of free bids, the Common Reference and the inclusivity of nomination baselines.

5.3. SP Energy Networks Objectives

This section describes how project FUSION has met SP Energy Networks Objectives.

Table 6: SPEN objective successes and learnings

DSO Data Transparency
Meeting the objective
✓ The FUSION project explored the data transparency of the processes and the experience of the trial participants. ✓ It explored how data transparency can be enhanced and the consequences this would have, understanding data as network, market and dispatch data. ✓ Full assessment of this objective is included in ITLR#3 (Section 4.2).
Learnings

○ It was confirmed that DSO did not have notable issues accessing or sharing data in the FUSION trial. Some initial technical issues, [96] were resolved and have not been encountered during this trial period.
○ Aggregators did not have issues accessing the data, but they had issues with data sharing:
  ○ OP encountered an internal issue aligning APIs with the code as there are many manufacturers using the submeter, meaning that there is a need for updates every time one of them changes their API.
  ○ Gridimp indicated that getting the MPAN data from residential assets is currently a tortuous process and getting the consumer to consent to the process is a challenge. This is an issue not only related to USEF and FUSION trial, but applicable to GB wider industry.
  ○ Gridimp stresses the importance of accessing the customer data and details regarding what assets there are and where they are, as they encountered the issue of some of the assets in the original list not being operational, and further assets that were not originally in the list being discovered. This is an issue not only related to USEF and FUSION trial, but applicable to GB wider industry.
○ The FUSION trial participants did not face data privacy concerns:
  ○ Aggregators were satisfied with the data trackability and traceability throughout the trial.

96 the metering data was rejected and had to be resubmitted by the aggregator, or the FlexRequest was sent but the aggregator did not receive it

- Aggregators found the selection process of availability contracts by the DSO transparent.
- Aggregators found less clear the utilisation bids selection process by the DSO and as a result the raised a number of questions to the DSO which were answered.
- Aggregators found the identification the service requested challenging and hard to automate, as this process is hindered by the different services having different service windows. This results in aggregators sometimes not identifying which bids are free bids and which are not.

Coordination with the ESO

Meeting the objective

✓To fulfil the objective 'coordination with ESO', co-ordination with the ESO on primacy rules was explored in the "primacy rules" trial in which SP Energy Networks via project FUSION and National Grid ESO collaborated between November 2022 and January 2023.

✓To complement this trial, a discrete study was also produced which focussed on the interaction between Short Term Operating Reserve (STOR)[97] providers and Active Network Management (ANM) generators in the same area where opposite instructions are issued by the ESO and DNOs. This is available here: 'Development and impact quantification of primacy rules.'

Learnings

This objective was primarily fulfilled by the implementation of a 9-month project in co-ordination with the ENA ONP, please refer the following for further reading:

- Trial learnings report: Primacy rules Implementation [98]

In summary, the trial scope was to demonstrate the implementation of Primacy Rule 1a to manage the 'Balancing Mechanism (BM) vs DNO Flexibility' use case. Particulalry, the trial tested a scenario where DNO has priority over the BM instructions and information on DNO flexibility services and conflicts is shared ahead of time: the DNO shares a weekly Risk of Conflict report with the ESO.
The basic process that was trialled consisted of 4 stages:

1. Balancing Mechanism Unit (BMU) data transfer of all contracted BMUs which are located within SP Energy Networks' distribution networks (from the ESO to SP Energy Networks).
2. Mapping of BMUs against Congestion Points which are managed by the DNO (by SP Energy Networks to the ESO).
3. Risk of Conflict (RoC) reporting, by SP Energy Networks to the ESO advising which BMUs represent a potential ROC the week ahead.

97 Section 4.4.3 of the FSP makes a commitment that the "flexibility services [trialled in FUSION] will include participation in [Short Term Operating Reserve] STOR". It should be noted that for Distributed Energy Resources (DER) to participate in STOR, a minimum of 3MW of generation or steady load reduction capacity is required. Unfortunately, none of the DER units recruited to participate in FUSION satisfied that criteria, and so FUSION was unable to trial participation in STOR. Despite that limitation, Project FUSION was able to produce the following: the following, relevant outputs:

i. A well-informed report on the interaction of Active Network Management with STOR

ii. A report into he findings of live trials that FUSION implemented with NGESO to test the primacy rules developed for managing the interaction of DSO flexibility and the NGESO Balancing Mechanism.

98 'Development and impact quantification of primacy rules.'
Trial learnings report: Primacy rules Implementation

4. Downstream ESO process implemented by the ESO to avoid dispatching those BMUs highlighted in the ROC report for the associated period.

A summary of the learnings from each stage of the process and the relevant recommendations are presented below:

Stage	Learnings	Recommendations
BMU data transfer (ESO)	The Balancing Mechanism Unit (BMU) data transfer provided to SPEN lacked reliable, high resolution geospatial data	Consider how improvements could be achieved to both availability and quality of data (particularly geospatial data).
BMU mapping (DNO)	BMU mapping to DNO congestion points was heavily manually and reliant upon human input	Consider opportunities to automate the processes to facilitate scaling, and what improvements to data might be required to facilitate those enhancements
'Risk of Conflict' (RoC) reporting (DNO	Those RoC reports communicated several instances of week-ahead conflicts having been identified	The report recommended to both ESO and DNO to consider implications of adopting this trialed approach into BaU and scaling it to accommodate the increase of flex services that we envisage in Q3 2023.
Downstream process (ESO)	Requirements for developing an enduring and scalable solution in ESO are now better understood and are being progressed	

5.4. Project Direction Deliverables

The Project Direction issued for FUSION articulated a set of 'Project Deliverables' and associated timescales, against which the successful completion of the project is evaluated. These are summarised below.

Table 7: Project FUSION deliverables

Ref	Deliverable	WP	Evidence	Source/ Availability	Status
1	**Report on flexibility quantification in E Fife**	2	Report on flexibility quantification in E Fife	Quantifying Flexibility Report	Completed
2	**Public consultation on USEF**	3	Deliver the consultation document on the basis of workshops	Consultation Document	Completed
			Hold an open consultation for a three-month duration	2 x Consultation events took place USEF Consultation Fact Card	Completed
			Report on consultation responses and analysis.	USEF Consultation Report – Full USEF Consultation Report - Executive Summary	Completed
			Report on associated changes to USEF implementation plan.	USEF Associated Changes Report	Completed
3	**USEF Implementation Plan**	3	FUSION USEF implementation	FUSION USEF Implementation Plan	Completed
			Report on GB specific reference implementation of USEF.	GB Reference Implementation of USEF	Completed
4	**USEF Process implementation**	4	Provide specification of communication and procurement platform	USEF Process Implementation Platform Communication & Procurement Specification	Completed
			Provide specification of communication protocols between market participants.	Specification of communication protocol between market participants	Completed
			Provision of template flexibility contracts	Flexibility Services Template	Completed
			Quantify market participant costs for implementing USEF interface compatibility.	Quantification of market participant costs for implementing USEF interface compatibility	Completed
5	**Implement a minimum of two physical and live trials of commoditised flexibility based on the USEF framework**	5	Identify two trial locations.	St Andrews and Leuchars	Completed
			Identify the required flexibility services available from flexibility providers	Expression of Interest (EoI) Response Form	Completed
			Contract for flexibility services.	Flexibility service agreement	Completed
			Undertake live trials	Live trial run from September 2021 to April 2023. All evidence is documented in the Interim Trial Learnings Reports (4 x reports)	Completed
			Report on the implementation and analysis of USEF Trials.	Trial Learning Report 4 - Final Instalment (April 2023) Interim Trial Learnings Report 3 (Dec 2022) Interim Trial Learnings Report 2 (May 2022) Interim Trial Learnings Report 1 (Oct 2021)	Completed

6	**Modelling report on commoditised flexibility benefits for the UK (Imperial College London**	**5&6**	Academic modelling report on GB flexibility.	Delivered February 2022, FUSION CBA Report	Completed
7	**Open Networks report in coordination with the ENA Open Networks Programme**	**6**	1. Report on coordination and hierarchies of control for flexibility, in collaboration with the ENA Open Networks Programme 2. Study into the interaction of Short Term Operating Reserve (STOR) providers and Active Network Management (ANM) generators in the same area where opposite instructions are issued by the ESO and DNOs.	1. Trial Learnings report: Primacy Rules Implementation (March 2023) 2. Development and impact quantification of primacy rules.	Completed
N/A	**Comply with knowledge transfer requirements of the Governance Document**	**6**	Annual Project Progress Reports which comply with the requirements of the Governance Document.	Yearly progress reports: FUSION Project Progress Report (Year 1) FUSION Project Progress Report (Year 2) FUSION Project Progress Report (Year 3) FUSION Project Progress Report (Year 4)	Completed
			Completed Close Down Report which complies with the requirements of the Governance Document.	This report	Completed
			Evidence of attendance and participation in the Annual Conference as described in the Governance Document.	Project FUSION has been represented at every Annual Conference since its commencement. 	Completed

6. Plan Variance

The following modifications were made to the planned approach for project FUSION, either as a result of external factors impacting the project, or to improve project outcomes.

6.1. Consultation

One of the conditions in project's FUSION Direction was a 3-month open consultation on USEF. Following detailed consideration, the project team decided to condense the consultation period to 2 months. A change request for this minor amendment was formally submitted to Ofgem well in advance of the consultation period. The rationale for this change was that it would:

1. Maintain the momentum and urgency of the consultation process to encourage early engagement and avoid stakeholder disengagement
2. Accelerate interim learnings by allowing earlier commencement of dependent activities
3. Align with ENA ONP practice, which typically allowed 8 weeks consultation period.

6.2. Duration of Live Trials

Live trials were initially planned to start in June 2021. Phase 1 of the live trial went live in September 2021. The delay did not have a material impact on the project performance and on the learnings from the trial. The cause of the delay was the additional time that was required to develop the FUSION Flexibility Platform (FFP) and to complete the testing processes prior to the trial going live.

6.3. Simulation of Congestion

In phase 1 there was no real congestion affecting any of the substations, and as such the cases were designed so that flexibility would be dispatched by simulating a number of plausible scenarios. Within each use case there are a number of test cases were designed depending on the day-ahead and intraday forecast of the substation load. Alleviation of real congestion was introduced in phase 2 of FUSION trial, which commenced in April 2022. It is worth noting that the simulations were executed according to a schedule that was designed to ensure that all test cases were trialled and that a high turn-over of events were achieved to maximise the volume of relevant empirical data generated for subsequent analysis within the boundaries of the contracts.

More details on phase 1 trial operation and simulation are provided in FUSION Interim Trial Learning Report #2.[99]

6.4. Covid – 19 Impact on Forecasting

During the first lock-down in Q1-2 2020, a 30% reduction in demand was observed at St Andrews Primary substation. It became apparent that the algorithms used to forecast

99 https://www.spenergynetworks.co.uk/userfiles/file/FUSION%20interim%20trial%20learnings%20report_final.pdf

demand on the network assets had to be re-calibrated (at least in the short-term) to accurately reflect changing customer behaviour and provide a robust solution for the 'new normal'. These modifications were made to the PRAE forecasting tool (i.e., SP Energy Networks forecasting tool) in time for the live trials which commended in Q3 2021 and were tested to confirm that they successfully resolved the issues encountered.

6.5. Flexibility Volumes

The initial plan for Project FUSION was to recruit 3MW of flexibility capacity, however it only managed to contract 1.5MW. Although this reduction in flexibility volumes did not have an impact on congestion management, it illustrates Project FUSION's difficulties in recruiting flexible assets which is also discussed in section 4.2 Additional Learnings for the DSO and in Submission Objective 2, section 5.2.

COVID-19 had a large impact on this recruiting. Many of the local customers, who represented flexible assets in the study area, belonged to sectors that have been particularly adversely impacted by COVID-19. COVID-19 measures including lockdown, furloughing, and temporary closures posed an obstacle to FUSION partners being able to engage with these customers. Nonetheless, the project has managed successfully to maintain momentum and stay on schedule by focussing efforts on advancing those FUSION tasks which were controllable and unaffected by COVID (e.g., platform procurement and integration).

In December 2020 FUSION concluded its first flexibility tender exercise to procure available flexibility for Phase 1 of the live trials. Whilst the exercise was successful in procuring all flexibility that was specified, none of it represented flexibility from the residential sector. Having residential customers participate in FUSION was important to gain insights into how innovative USEF features (like 'free bidding') might serve to improve the accessibility of residential customers participating. In the interest of recruiting residential customers to participate in the trial , FUSION launched a dedicated Facebook campaign in 2021 which promoted the FUSION flexibility market and successfully recruited local homeowners to participate in the trial via one of the existing contracted aggregators. The continuous effort to promote FUSION (and USEF features) to residential customers as well as raising the free bids price cap in phase 2 of the trial encouraged additional residential flexibility participation.

7. Cost Variance

7.1. Summary of Significant Variance

Project FUSION has underspent by 15% relative to the forecast expenditure. A breakdown of this variation is provided below in **Error! Reference source not found.**.

Table 8: Variation between forecast & actual expenditure.

Costs until 01-Feb-24 (£)	Cost Categories										
	Labour	Equipment	Contractors	IT	IPR Costs	Travel & Expenses	Payments to users	Contigency	Decommissioning	Other	Total
Forecasts (FSS)	1,668,656	332,765	2,916,630	300,000	-	181,214	220,000	51,780	-	-	5,671,045
Actuals (incl. Accruals)	1,393,689	-	3,414,453	-	-	-	-	-	-	-	4,808,142
Variation (%)	-16.48%	-100.00%	17.07%	-100.00%	0.00%	-100.00%	-100.00%	-100.00%	0.00%	0.00%	**-15.22%**

7.2. Justification for Observed Variance

A summary explanation for the observed variations is provided below in **Error! Reference source not found.**.

Table 9: Explanation for perceived variations in expenditure

Cost Category	Variation	Explanation

Labour	-16%	• Efficiency to leading and delivering the project was optimised. Therefore, lesser than the planned SPD staff was assigned and charged to the projected.
		• Level of actual variation to this category is actually ca. -30%, since the Labour category included the cost types given below;
		  ○ SPD Staff Cost associated with the submission of the FUSION proposal for approval by the regulator, and the project delivery
		  ○ SPD travel expenses
		  ○ Any contingency costs

Equipment	-100%	• The equipment budget originally accounted for the cost of the sub-metering equipment that would be required as part of the WP2 flexibility quantification exercise, and for the cost of the DSO Platform (hardware) • The sub-metering equipment for was used, but their cost was accounted for under the 'Contractors' cost category. Hence the

		equipment cost category shows a variation of 100%, but there in fact is no variation.

Contractors	+17%	• The variation is appearing since this Contractor category bundled 5 different types of costs given below;
		  o Equipment,
		  o Contractors
		  o Contractors travel expenses
		  o IT, and
		  o Payments to Users
		• Otherwise, like with a like comparison informs an ca. 10% underspend due to agile nature of contractual arrangements and by maintaining enhanced efficiencies.

IT	-100%	• The IT budget accounted for the DSO Platform (software) and its integration with DNO and aggregators' systems. • The DSO Platform was successfully procured, and any costs associated with maintenance and enhancements in this reporting period were accounted under the 'Contractors' cost category. Due to which, we find zero costs in the 'IT' cost category or 100% variation albeit there're payments made for the IT.

Travel & Expenses	-100%	• Rather than being captured separately, travel costs were accounted for under the 'Contractors' and 'Labour' categories.
		• (Most of the stakeholder engagement work has been completed by SPD, with the associated travel & expenses being captured under the 'Labour' cost category).
		• Consequently;
		  o the variation in the 'Travel and Expenses' cost category is 100%
		  o the 'Labour' cost category has been inflated

Contingency	-100%	• This small contingency budget was provided to cater for unexpected costs that did not fit within any of the above categories.
		• Because most of the key deliverables to-date relied on fixed-fee Call-Off agreements with Partners, any unexpected costs were either borne by the Partner or absorbed by deploying in-house Labour from the Licensee.
		• Consequently:
		  o the variation in the 'Contingency' cost category is 100%
		  o the 'Labour' cost category has been inflated

7.3. Assumptions Used & their Limitations

7.3.1. Accrued costs

When expressing the actual expenditure for the FUSION Project during the reporting period (see Section 7.1) the following 'accrued' costs have been included as at 5th Feb 2024.

These costs have not yet been invoiced for, but the associated work was completed by the cut-off date. Therefore, the costs are accounted for as having been already 'accrued';

Table 10: Accruals (Feb 5th 2024)

Accruals till Feb 2024 awaiting invoices		
Cost Category	**Detail**	**£**
Contractors	Contractor - Proj Partner DNV GL	22,680
Contractors	Contractor - Proj Partner Origami/Barringa	1,465
Contractors	Contractor - Ove Arup	30,000
Total		**54,144.99**

7.3.2. Indicative Costs beyond Feb 2024

The Following costs are expected to be realised during the period Feb-Jun 2024.

These costs have not yet been invoiced or accrued as the associated work is currently in progress.

Once the work has been completed and paid for, the overall project cost reported in Section 7.1 is expected to increase by ca. £35k.

Table 11: Remaining project costs

Indicative costs from Feb2024 - June 2024		
Cost Category	**Detail**	**£**
Labour	Labour - SPD - Q1 2024	15,000.00
Contractors	Contractors - ARUP	20,000.00
Contractors	Contrators - Origami	75.00
Total		**35,075.00**

Taking into account the indicative remaining cost of ca £35,000, the total amount of unspent funds from the project is expected to be ca £828,000[100].

[100] *£5,671,045 – (£4,808,142 + £35,075) = £827,828*

8. Business Case

8.1. Summary of the Original and Updated Business Case

Following the original business case that formed part of the Full Screening Process for project FUSION's approval by Ofgem, an updated CBA was carried out in February 2023 using trial learnings and wider developments in the understanding of flexibility markets.[101] This updated CBA for a USEF-based flexibility market continued to demonstrate significant GB-wide benefits and the potential for local level in the future.

The original business case was assessed against a counterfactual of bilateral flexible trading agreements between industrial and commercial customers and the DNO. In this regard the original CBA differs from the updated CBA which measured the incremental costs and benefits against a BAU-based flexibility market, making direct comparison of the outcomes of each CBA challenging.

The main benefits in the updated CBA are premised on the assumption that a USEF-based market will encourage higher residential participation and high reliability. The evidence for this assumption was the higher residential participation observed in the FUSION trial compared to the residential participation that was observed in existing flexibility markets that operate in the UK. It is worth noting there is insufficient evidence to indisputably claim a direct causal al link between USEF and residential participation at this stage. In addition, we acknowledge that flexibility markets have evolved since project FUSION started and recent developments in GB flexibility markets also suggest that the CBA assumptions for future residential participation in the counterfactual may be underestimated, namely:

- Relatively high residential participation in the recent 2023 Scottish Power Energy Networks' flexibility tenders out to 2028; and
- Success of the National Grid ESO winter 2022 Demand Flexibility Service that saw significant residential participation.

Results of the updated CBA must therefore be read in this context.

Table 12 summarises specific expected benefits from a USEF-based flexibility markets, which were used as inputs to derive the outcomes of the respective CBA's.

Table 12: Assumption to calculate the Original and updated Business Case for a USEF-based Flexibility Market

Benefits	Original Business Case*[102]	Updated Business Case	Commentary
Increasing Residential Participation	Qualitative increase and widening of participation from	USEF would enable GB to adopt high volume of flexibility from residential	Similar discussion in original and updated business case

101 FUSION_CBA_report_Feb_2023.pdf (spenergynetworks.co.uk)
102 fusion_-_fsp_redacted_29_11_2017.pdf (ofgem.gov.uk), Section 3

	non-industrial and commercial customers such as residential assets	sector observed in the FES System Transformation and Consumer Transformation scenarios	
Increasing Reliability of Delivery	No reference to this in original business case	Increase reliability compared with other flexibility innovation project results from 65% to 80%	Only referenced in updated business case
Lower USEF Enablement Costs	23% lower hardware and software investment costs due to USEF standardization	Increase in incremental USEF enablement cost of £147k compared to BAU flexibility market, which was incurred by both aggregators and the DNO	Updated business case has a different counterfactual, turning USEF enablement from a benefit to a cost
Lower Ongoing DNO Management Costs	20% lower ongoing DNO costs through a reduction in the need for full-time employees to manage commercial agreement	No reference to this in updated business case	Only referenced in original business case
Lowering Availability Costs	29% lower availability costs due to shorter duration of availability contracts	High availability costs were used as input in the updated business case reflecting the availability prices of the trial	Availability costs were an input in the updated business case, rather than an output
Lowering Utilisation Prices	20% lower flexibility utilization prices with USEF's real-time visibility and competition facilitation	Utilisation costs were used as input in the updated business case reflecting the utilisation prices of the trial	Availability costs were an input in the updated business case, rather than an output
Increasing Network Reinforcement Deferral Time	More than a halving of the average deferral of network reinforcement	The assumed reinforcement deferral is 4 years.	The deferral time was an assumption of the updated CBA, and the savings were calculated based on 4-year deferral assumption.

* Original business case was assessed against a counterfactual of bilateral flexibility trading arrangements with industrial and commercial customers. This contrasts with the updated CBA which used a BAU-style flexibility market as the counterfactual.

The key drivers for the benefits seen in the updated CBA were an increase in the reliability of delivery for local benefits and an increase in participation from residential assets or wider GB benefits. The increase in reliability was observed in data from the FUSION trial and compared against results from other innovation projects looking at flexibility markets. The high residential participation was also observed during FUSION trial (80%). The potential factors (e.g., day ahead trading, free bids, common reference, standardisation and automation) which could have led to this high participation of non-firm assets have been discussed extensively in section 4.2 and in Submission Objective 2, section 5.2.

With sufficient market liquidity, a USEF market could reduce the need for availability payments as non-firm capacity could provide all flexibility needs.

Since FUSION's inception in 2018, contracted flexibility capacity has increased from 110 MW to approximately 2 GW in 2023 in GB[103]. None of the DNOs has adopted USEF as part of its business-as-usual flexibility markets. However, USEF still offers valuable features that are influencing DNO's evolving strategies:

- Real-time flexibility trading allows market participants to make quick and informed decisions based on real-time market data. Additionally, it enables market participants to react swiftly to changing market conditions, which is crucial in a flexible market environment. Day-ahead flexibility trading will be implemented during the use of the Piclo dispatch module in the 2023 winter day-ahead trials for the first time;
- Secondary trading is also part of the BAU medium to long term development roadmap of the Piclo dispatch module.
- Valuable learnings from FUSION will aid BAU in investigating how flexibility can achieve real-time forecasts of network needs.
- A single end-to-end process for procurement and operation of flexibility services. Historically, the end of end process for has involved multiple organisations without a single, standardised common framework, however this is changing as companies such as Piclo are also involved with dispatch as well as procurement.
- Whole system modelling with conflict avoidance protocols that allows market participants to interact seamlessly and reducing the risk of conflicts arising (e.g., with National Grid ESO).

8.2. Original Business Case

The original business case in the FSP was built on creating value to for local areas, customers, GB, National Grid ESO, aggregators and suppliers.

Benefits in East Fife: At a local level, it was estimated that a flexibility market in East Fife would represent a saving of £19m by 2050 compared with the counterfactual. These savings would filter down to customers through lower DUoS costs.

Benefits for GB: The business case used a bottom-up approach to scale benefits up across GB based on the ratio of peak demand. The expected benefits for GB electricity customers were in excess of £236m by 2050 and that it would "unlock" up to £3.5billion per annum by 2050 (based on estimates for the role of flexibility in the future UK electricity system). Significant carbon savings in the form of losses reduction and renewable energy replacement were forecast at over 3.6m tCO_2 by 2050.

Benefits for Customers: Customers, including industrial and commercial, were also expected to benefit from the additional revenue opportunities offered by these markets, more reliable network and an acceleration in the delivery of new connections.

Benefits for National Grid ESO: The business case also assumed that National Grid ESO would benefit from increased access to market participants for national balancing. The

103 Great Britain reaches new record in contracted flexibility – Energy Networks Association (ENA)

project would promote synergies between ancillary services for National Grid ESO and local flexibility services as the same flexibility could be used for multiple purposes.

The project was also seen to be supporting the development of aggregators in flexibility markets more generally, which was outlined as a key strategic necessity at the time[104].

Benefits for energy suppliers: Finally, energy suppliers would also benefit from the fact that flexibility providers have to register as a trading party or partner with them in order to participate in markets, opening up new revenue streams for themselves.

8.3. Updated Business Case

An updated CBA was carried out once trial data was available, which explored the additional future value of USEF-based flexibility trading against the, now, conventional market-based flexibility procurement. The analysis estimated the incremental benefits of implementing USEF to bring local area benefits through managing local distribution network constraints and to support wider GB national balancing requirements.

Benefits for Local Network: Local area benefits were explored in the updated business case through an investigation of how flexibility contributes to localised security of supply (decreasing Customer Minutes Lost – CML) and the benefits of deferring upgrades in the local distribution network.

The approach to measure the flexible assets contribution to the network's security was firstly to estimate the demand reduction that could be achieved with flexibility for a typical peak day profile and then to establish the effective contribution of flexibility to security of supply. The Effective Load Carrying Capability (ELCC) approach was used to establish the potential increase in demand enabled by enhanced flexibility that would maintain the same level of risk as with the original demand level without flexibility. The ELCC approach considered the reliability rates of flexibility providers that were observed empirically during the trial (Figure 23).

The ENA's Common Evaluation Methodology (CEM) tool quantifies the monetary benefits of the increase in demand enabled by flexibility resulting in both network upgrade deferral and Customer Minutes Lost (CML) reduction (Figure 22). The basis for the difference between USEF and BAU flexibility was FUSION trial data, which demonstrated an improvement in the reliability of flexibility delivery compared with previous flexibility innovation projects: from 65% to 80%.

104 Ofgem - Aggregators - Barriers and External Impacts May 2016

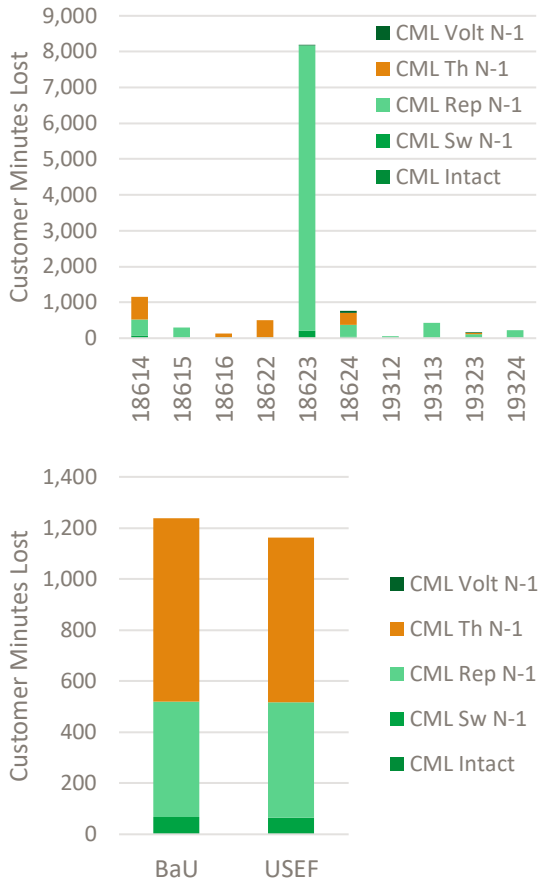


Figure 22. CML for a) USEF-based flexibility and b) difference between BaU- and USEF-based flexibility scenarios for feeder 18614 (the only feeder where difference is observed).

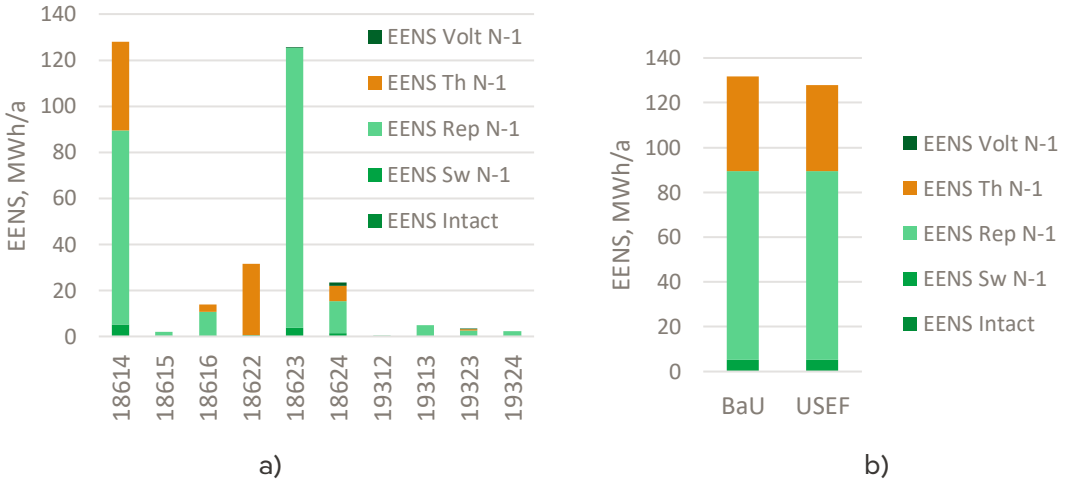


Figure 23. EENS for a) USEF-based flexibility and b) difference between BaU- and USEF-based flexibility scenarios for feeder 18614 (the only feeder where difference is observed).

Potential savings from USEF-based flexibility resulting from both network upgrades and Customer Minutes Lost (CML) reduction: In two out of three HV feeders where FUSION trial flexible assets were connected, there was no network congestion observed. Therefore, there were no estimated benefits from flexibility. The estimated potential savings from flexibility on the one congested feeder were £6-7k. When comparing USEF-based and BAU-based flexibility, the additional savings from USEF-based flexibility were £996, 17% higher than the benefits of BAU-based flexibility. These savings were from both network reinforcement deferrals and CML reductions.

USEF – enablement cost for DSO and aggregators: The incremental cost associated with enabling USEF over BAU in the trial, was estimated at £147k, which is incurred by both aggregators and the DNO.

USEF – operating costs (i.e., flexibility payments): After factoring in the availability and utilisation prices seen in the trial, the cost of FUSION-based flexibility, if utilised in a pre-fault manner, was approximately £2 million.

Net benefits of USEF- based flexibility market in East Fife: There is no net benefit in this respect as the implementation and operating costs is noted that the higher prices in FUSION were needed to incentivise flexible providers to participate in the innovation project and therefore are not reflective of a fully established market.

It is important to note that the benefits of USEF-based flexibility may be negative, but they apply to a small number of feeders, some of which are loaded at a relatively low level. Demand changes during COVID may have contributed to this lower-than-expected loading on the feeders therefore pre-trial loadings may have been more representative of near-term future conditions. As the demand for electricity continues to rise with the electrification of the heat and transport sectors, the benefits of FUSION are expected to significantly increase, due to higher network loading and unlocking additional sources of flexibility.

GB Wider Benefits of USEF-based flexibility: The GB-level benefits of USEF were derived from the premise that FUSION would unlock additional sources of flexibility from the residential sector.

The updated CBA adopted assumptions on the volume of flexibility available in the residential sector through electrified transport, heating, and smart appliances. These assumptions were based on the demand side response (DSR) assumptions featured in two of National Grid ESO's Future Energy Scenarios (System Transformation (ST) and Consumer Transformation (CT)). It was assumed that this level of flexibility would be enabled, at least partially, through concepts such as FUSION. To illustrate this amount of flexibility, the DSR capability was expressed in terms of the fraction of peak demand that can be shifted in 2050 (see table below).

Table 13 Assumptions on residential flexibility provided by EVs and heat pumps with and without FUSION

	With FUSION		Counterfactual – no FUSION	
	System Transformation	Consumer Transformation	System Transformation	Consumer Transformation

Residential participation	Actual FES assumptions on residential DSR		Reduced volume[105] of residential DSR compared to FES assumptions
EV Flexibility – peak demand that can be shifted by 2050	27%	40%	10%
Heat Pump Flexibility - peak demand that can be shifted by 2050	25%	50%	5%

To investigate a "no FUSION" case study, the DSR available from distributed residential resources was scaled down. This reflects a situation where the bulk of distributed flexible resources remains underutilized due to lack of a suitable market framework. The flexibility of smart appliances was not considered in this case study, while the flexibility of EV demand and heating demand was reduced to 10% and 5%, respectively. These assumptions were made based on expert judgment from the Imperial College London team. As indicated in earlier sections of this report, flexibility market has evolved since project FUSION started and the familiarisation of aggregators and flexibility providers with DSO flexibility markets have improved. In addition, whereas residential flexibility has not been deployed between 2017 (when FUSION started) and 2022, GB DSOs and particularly SPEN have started reporting increased number of contracting residential flexibility. As such, the CBA may have underestimated the uptake of residential flexibility, and EVs and heat pumps' flexibility in the counterfactual (no FUSION) flexibility market scenario.

Figure 24 shows the reduction in total system cost enabled by FUSION for each scenario and time horizon. This reduction is quantified as the difference in total system cost between the scenario with FUSION implemented and the corresponding scenario without the additional flexibility. The difference between scenarios is driven by the increasing volume of electrified transport and heating demand, which results in higher absolute level of flexibility unlocked in these sectors also through the deployment of FUSION.

105 We acknowledge that the CBA may have underestimated the uptake of residential flexibility in the counterfactual flexibility market scenario.

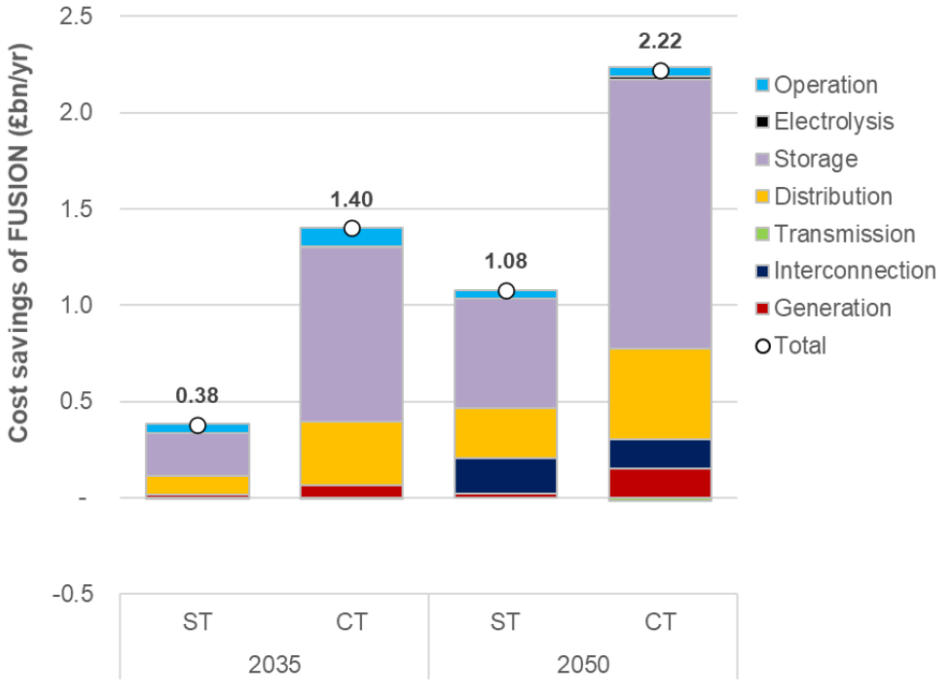


Figure 24: GB-level Cost Savings due to FUSION

The results show that the system benefits of FUSION materialise in various system segments, including:

- Reducing the requirements for distribution network reinforcement that would otherwise be required to accommodate high demand peaks associated with electrified transport and heating;
- Reducing the requirement for peak supply capacity (storage and generation) due to the ability of FUSION-enabled distributed flexibility to shift electricity demand from peak to off-peak periods;
- Reducing the operating cost (OPEX) of thermal generation, mostly unabated gas CCGT generation and BECCS;
- Reducing the requirement for other means of flexibility such as interconnectors;
- FUSION reduces the need for peak supply capacity by lowering net peak demand. Battery storage capacity replaces most of the displaced peaking capacity mentioned in the study, but FUSION could also displace zero-carbon peak generation capacity like hydrogen-fuelled OCGTs.

The flexibility enabled by FUSION could significantly reduce net peak demand in 2050, with the distribution grid's net peak loading decreasing from 93 GW (ST) and 119 GW (CT) in the no-FUSION cases to 84 GW and 104 GW, respectively. This would have a direct positive impact on the required peak supply capacity (e.g., battery storage or peak generation) and distribution network reinforcement, potentially resulting in substantial cost savings.

When quantifying GB-wide implications of FUSION deployment using statistically representative distribution networks, based on the outputs from independent team from

ICL's whole-system model, the benefit of FUSION for network reinforcement deferral in 2035 is estimated at £8.1-8.7bn, and in 2050 it is estimated between £2.1-4.4bn. The highest savings are observed in suburban networks followed by urban and rural networks. This difference is caused by the greater length of HV assets per customer in these areas.

The cost of implementing and enabling residential flexibility ranges from 40% to 70% of the gross benefits of the whole system. In the System Transformation scenario, the net system benefits in 2035 are £216 million per year, while in the Consumer Transformation scenario, the net system benefits in 2050 are £654 million per year.

FUSION has a net present value of system benefits ranging from £2.9 billion to £5.8 billion across the various scenarios. From a whole-system perspective, FUSION has a compelling business case as its overall net present value remains positive even after factoring in the implementation and enablement costs.

8.4. Noteworthy Developments

During the project, the network in the area selected for the trial was less heavily loaded than anticipated, resulting in less need for flexibility. This may have been a result of the reinforcement of a neighbouring primary at Eden Campus. The impact on the trial was that all congestion in phase 1 had to be simulated since there was only a limited amount of real congestion in the physical assets. A data preparation tool was developed to adjust real forecasting data and the maximum power profile of the selected substation to simulate the different test cases (see also section 6.3 for details). In the CBA, only one of the feeders studied required reinforcement, therefore, only a small gross benefit was observed from flexibility in the trial area.

Finding local flexibility to participate was also challenging as only 1.5MW was obtained out of the targeted 3MW. Lower flexibility volumes were contracted due to challenges with recruiting flexible assets (see also section 6.5 for details), the lack of a long-term need for flexibility and the reluctance of prospective aggregators to invest time in developing a USEF-compliant protocol that may not be used elsewhere.

8.5. Noteworthy Issues Encountered

Several noteworthy issues were encountered during the project that may have impacted the business case. Throughout the trial, the aggregators experienced challenges in defining an accurate baseline against which flexibility delivery and settlement was calculated. This was due to the small portfolio sizes which are inherently harder to predict the behaviour of and a general lack of technical capability in how to define a baseline for different types and portfolios of assets. A review of the trial reliability after considering the accuracy of the aggregators' baselines showed that this created uncertainty around the measured reliability that was used as part of the CBA as it was more difficult to estimate the exact volume flexibility that was delivered.

The project also encountered challenges with the way that flexibility was contracted. Availability payments to deliver the contracted Flexibility Service during the service window, were significantly higher than potential utilisation payments for delivering flexibility. Due to a combination of this difference and the way that aggregators were penalised on their availability payment for failing to deliver flexibility, aggregators were

incentivised to offer higher prices to discourage the DSO from activating flexibility. One explanation for this is that the potential loss in availability payments from being penalised outweighed the possible benefits from utilisation. Therefore, aggregators, who are obligated to offer flexibility, do so at the highest price possible to reduce the possibility of being utilised and running the risk of failing to deliver. Alternatively, due to the high wholesale price of electricity during the trial, aggregators may have been able to earn more through normal continuation of supplying power to grid; particularly true for the CHP plant. These contrasting incentives will have impacted how aggregators participated in the trial including their likelihood to overdeliver and will have impacted the overall estimated reliability of delivery (potentially in a positive direction). During Phase 2 of the trial, the penalties for under delivery were reduced to minimise their impact on the trial results.

As described in previous sections, FUSION was not able to effectively utilize free bids. This led to a significant underutilization of one of the USEF innovative elements. The CBA did not factor in the ability for free bids to lower overall availability costs, because they can provide flexibility outside of availability contracts, and increase asset availability, therefore may have underestimated the local benefits of a USEF-based market.

Finally, one of the key components for the trial set up was the FUSION Flexibility Platform (FFP) which supported the delivery of the flexibility. SPEN in collaboration with FUSION partners, developed a series of functional requirements that the FFP should meet, largely based on the USEF process descriptions. Opus One's FUSION flexibility platform (FFP) did not include several features that would have allowed the trial to explore additional benefits of FUSION, including for whole system analysis and automated settlements, and the request for improvements to the current version was denied.

9. Lessons Learned for Future Innovation Projects

Project FUSION was a complex project involving a partnership of six companies and collaboration with two aggregators – following a tendering process. In addition to the findings directly derived from the trials, lessons on the following topics which can be useful for network operators planning future innovation projects are presented below. This chapter presents both highlights from successfully running an innovation project as well as the challenges which were encountered within 4 years of delivery.

9.1. Highlights

Supporting Small – Medium Enterprises (SMEs): Both aggregators that participated in FUSION trials acknowledged that an innovation project as FUSION is a great enabler to smaller business getting familiar and participating in flexibility markets. They highlighted that innovation projects which give time, support and clear structure for smaller businesses and aggregators can be the perfect starting for such initiatives. Future innovation projects could learn from this experience and establish processes and methodologies which enable the participation of smaller businesses as this can bring a twofold outcome:

1) Small businesses have a great opportunity to learn, expand their skills and capabilities and develop tools that can use into BAU;
2) When network companies collaborate with partners which are keen to develop further as business, encounter less challenges and resistance with required changes or the implementation of new processes. In addition, these partners have the potential to continue collaboration with the network company.

Stakeholder Engagement to Refine Approach: Engagement with stakeholders played a crucial role in refining the direction of the project and steering it towards success. While staying true to the original project plan, new sub-goals were introduced that aligned with the changing needs of the industry. Following the initial consultation back in 2019, the elements to be tested in the trial were re-evaluated and certain ideas were abandoned. [106] In addition, the project introduced the USEF innovative elements learnings in addition to initial FUSION objectives in order to provide more disaggregated learnings and findings to FUSION's stakeholders.

Changing Flexibility Landscape: FUSION has effectively kept up with the rapid and constantly shifting landscape for flexibility in GB and has successfully modified its strategies to meet the changing market needs, from when the project was defined in 2017 to now, while still staying committed to its primary objectives. For example, the project has added more learnings from USEF innovative elements which address critical topics

106 For example, one of the initial ideas was to explore various aggregator implementation models in the FUSION trial. This idea was not taken forward due to its complexity but also due to the fact that the findings for GB industry would be less valuable and critical at that point of the flexibility markets development stage.

identified from other ongoing flexibility markets (e.g. improving baselining and assessing shorter term procurement), whilst it has de-prioritised other topics which were not a priority for flexibility markets (e.g., aggregator implementation models and independent aggregation). In addition, project FUSION has collaborated with TRANSITION in refining baselining design learnings Finally, project FUSION was collaborated with ENA ONP, to support industry learnings around primacy rules; primary rules were only recently developed in GB and there were not a priority when project FUSION started back in 2019.

Collaboration with ENA ONP and other innovation projects: The collaboration on key activities with ENA Open Networks Project (ONP) and other innovation projects has led to valuable learnings for GB industry. Project FUSION supported ONP Workstream 1A Product 5 and completed two key activities:

1) Development and impact quantification of primacy rules focussing on the conflict between STOR and ANM.[107]
2) Performed a 'primacy rules' trial in which SP Energy Networks (Project FUSION) and National Grid ESO (NGESO) between Nov 2022 and Jan 2023.[108]

9.2. Challenges

Site Selection - In the East Fife region:

a) there was a shortage of available flexibility and a lack of participation from aggregators. Although project FUSION did perform a quantification market assessment prior to the commencement of the trial, the final contracted flexibility was much lower than initially forecasted. The reasons cited included the commitment of time required for USEF development, the absence of sustained demand in the area, and lack of industrial and commercial activities beyond the University of St Andrews and NHS Scotland facilities. In addition, COVID19 impacted the engagement opportunities of project FUSION partners. In order to encourage further participation project FUSION paid over the odds to financially incentivise aggregators and developed a plug-in to remove barriers to newcomers in subsequent rounds of the trial.
b) In addition, there was lack of demand for flexibility as there were no constraints observed in the network. Network upgrades in the region reduced the business case for flexibility, whilst COVID19 also led to demand reductions. This was managed by simulating flexibility requirements as discussed in section 0

It is recommended that future innovation projects which involve a trial, take a more flexible approach in the selection of the trial location and select an area which better serves the objectives of the trial. For example, regular re-assessment of the location and its ability to meet trial's criteria could provide sufficient evidence for a DNO to select a different site/region.

107 https://www.spenergynetworks.co.uk/userfiles/file/on22-ws1a-p5-primacy-rules-cost-benefit-analysis-final-report-13-dec-2022.pdf
108 https://www.spenergynetworks.co.uk/userfiles/file/ONP_P5-trial_learnings_report_March_2023.pdf

With regard to recruiting more flexible assets, aggregators suggested that more money and effort should be spent on recruiting, and particularly in educating people that are not familiar with flexibility. The recruitment of domestic flexibility was a positive highlight of the project that may not have occurred without FUSION engagement with the community and aggregators. In developing new flexibility markets, there is a huge piece of work and effort in enabling the assets.

Single Suppliers Risks: Future innovation projects should carefully consider intellectual property and vendor lock-in to maximise the potential for using products that are developed in the future. In FUSION, the platform developer who developed the FFP refused the request to quote for enhancements to the DNO Platform, which limited the potential for project FUSION to explore transition into BAU and additional learnings and findings.

Governance, Roles and Responsibilities: During the early stages of the project, FUSION faced challenges in clearly defining the responsibilities of each partner in the collaboration agreements. This was due to the high number of unknown factors at the time. To address this, the project adopted a flexible approach by using collaboration agreements with call-offs. This allowed the project team to call off specific activities as and when the need for them was identified and confirmed. In addition, project partners regularly participated in collaborating workshops to plan next steps and allocate responsibilities across tasks and maintained bi-weekly meetings for the whole period of trial planning, implementation and operation.

Quantifying benefits and outcomes of the project: As the CBA has shown, the potential benefits from a project such as project FUSION are varied and are likely to accrue over a significant period. As a result, measuring future value at a network or GB scale of USEF-flexibility is particularly difficult and uncertain. Methods like flexibility need to be designed to overcome local constraints, where the demand for such flexibility is really high and there is liquidity in the market to take advantage of innovative elements of a project. In addition, the implementation cost during an innovation project is typically higher than when a solution turns to BAU and is implemented at a wider scale (e.g., benefits of economies of scale) and as such the benefits of the trial could be distorted. It is therefore important to consider the full range of potential benefits and the social impact on non-network parties to assess the benefits of project methods.

10. Project Replication

The following section summarises the main components to support future replication of the project and presents a list of all components and knowledge required to reproduce the project outcomes. It is worth noting that since the start of the FUSION trial, all DNOs have already implemented local flexibility markets to some extent. This means that most of the physical components and IP required to run a flexibility market are already available. The key differentiator of FUSION is its implementation of USEF and its innovative elements. Please also refer to sections 3.4 and 4.6 of this report for more information on how the FUSION's method can be replicated.

10.1. Trial Components

The key components required to replicate FUSION can be divided by their associated phase in the USEF Market Coordination Mechanism (MCM) (Figure 25) and have been summarised below (Table 14).

Figure 25: USEF Market Coordination Mechanism phases

A detailed list of the requirements for FUSION trial participants from a functional, technical and security perspective are detailed in the FUSION Communications Protocol document[109]. In addition, project FUSION has published the specification of the communications protocols between market participants. [110]

The UFTP APIs are open sourced and available at SHAPESHIFTERS (ex – USEF) website. This is not called SHAPESHIFTER library and is written in JAVA. [111]

Table 14: Trial Components Required for Replication of Trial

MCM Phase	Component	Detailed Information
Contract	Flexibility service agreement (FSA)	Full terms and conditions of the provision of flexibility services and define the responsibilities of and the interactions between the Aggregator and SP ENERGY NETWORKS. a contract in place for the service received from their prosumers[112]
	New flexible asset recruitment strategy	A strategic approach to recruiting new assets for participation in the market
Plan	DNO trading platform	A FUSION Flexibility Platform was developed to implement the MCM that adhered to the UFTP.

109 Specification of communication protocols between market participants
110 D4.2_specification_of_communication_protocols_between_market_participants.pdf (spenergynetworks.co.uk)
111 https://github.com/shapeshifter/shapeshifter-library-java
112 Flexibility Services Agreement Template

		For more details refer to communication and procurement specification[113]
	Aggregator and DSO simulator	For the purposes of the USEF compliance test and the User Acceptance Test
Validate	Forecasting tool	Tool to be capable of 5 day-ahead forecast and 6 hourly updates
	Congestion on the network or a tool to simulate congestion	To dispatch real-time flexibility in response to simulated or real congestion on the network. If required, the test cases can be simulated by adjusting forecast and maximum power profiles, by adjusting real PRAE forecasts to simulate the event with the help of a tool
	Aggregator baselining capabilities	Tool to accurately create a baseline power demand/generation without flexibility activation. To be used for settlement
Operate	Flexible asset monitoring and control equipment	Capability to monitoring assets in real time
Settle	Settlement Calculator	Settlement calculator that is able to compare meter data with aggregator baselines from the FFP
All	Sub-metering for all flexible assets	Metering needs sufficient accuracy, in line with the product specifications
	Message encryption method	To securely transmit and authenticate USEF messages

10.2. Knowledge & Skills

The knowledge and skills required to successfully replicate the project has been divided into the key trial participants and summarised in the table below.

Table 15: Knowledge Required for Replication of Trial

Stakeholder	Detailed Information
Trial project manager	Competent project manager that should navigate across complexities, uncertainties and engage with a range of stakeholders.
IT developer	Development and testing of the flexibility trading platform. IT capabilities are required. It would be beneficial for the develop to have prior experience with the USEF Framework and UFTP.
Flexibility asset owners	Require long-term forecasting capabilities for the assets that will be used to meet its obligations of each availability contract
Aggregators	Internal aggregator processes must either comply with UFTP or aggregator must have access to aggregator simulator. Includes baselining expertise and ability to handle large datasets such as meter data.
Flexibility platform operator	This role was successfully fulfilled by an power engineering graduate, who was trained in how to interpret and operate the user interface of the FUSION dispatch platform.
DSO	Must be able to comply with UFTP including long and short-term forecasting capabilities

113 USEF Process Implementation

10.3. Intellectual Property

FUSION recognises the importance of knowledge sharing between DNO's and across industry. USEF is a flexibility market framework and is separate from any software-based flexibility procurement platform that is used to implement it. SHAPESHIFTER is the re-branded name of the UFTP protocol which will be maintained by the GOPACS organisation. The SHAPESHIFTER protocol has also been adopted by the Linux Energy Foundation, offering a platform for the ongoing maintenance and support of the protocol. Shapeshifter has developed a reference implementation (RI), through which the concept and mechanism of the USEF framework can be tested and verified in field trials. The USEF RI is open-source and USEF does not impose or require any intellectual property rights.

Opus One developed GridOS®, their existing software solution, as the basis for the FUSION Flexibility Platform (FFP).

Access to any foreground intellectual property can be requested via the contact details provided in Section 0:

Data Access Details.

11. Adoption into BAU

This chapter distils some of the ongoing considerations around the extent and speed at which SP Energy Networks will adopt the learnings from the FUSION trial into BaU.

11.1. Plans for Adoption within SP Energy Networks

11.1.1. BaU Flexibility Services

Prior to the start of ED2, the 'Flexibility Services' team of SP Energy Networks began testing the market for flexibility services and are committed to fair and transparent procurement of flexibility services.

We began tendering for flexibility services in 2019, but the level of services required increased significantly in 2020 and 2021, when we tendered for all locations with manageable constraints arising from forecast load growth during the RIIO-ED2 period (2023 to 2028). We sought a total of 1.5GW of flexibility services at 1,557 locations across our two licence areas and covering all voltage levels. To date, we have accepted bids for over 700MW.

This BaU flexibility activity was conducted in isolation from (but in close liaison with) the FUSION trials, which were operated in parallel to them.

11.1.2. Obstacles to Adoption

One of the most significant obstacles to adopting the FUSION dispatch platform is itsreliance upon a manual settlement processes. That, coupled with OpusOne's refusal to develop the platform further to automate the settlement feature, makes scaling the solution to cope with high volumes of settlements impractical.

SP Energy Networks also has a duty to honour its existing obligations to flexibility services providers which have been contracted to date, and whose Flexibility Service Agreement (FSA) contracts were not drafted with USEF's Market Coordination Mechanism (MCM) in mind.

Whilst the FUSION dispatch platform is not regarded as an entity which can justifiably be considered for wholesale adoption by BaU in te short term, SP Energy Networks is evaluating how discrete FUSION learnings / innovative features could feed into and enhance our BaU processes and policy developments in the future.

That evaluation is cognizant of the complex and rapidly evolving technical and commercial and regulatory landscape in which Flexibility Services operate and recognises that none of the solutions available today will be able to satisfy the business's short-, medium- and long-terms needs.

- Short term: BaU flexibility services need to deliver upon our existing obligations
- Med term: Some FUSION learnings are likely to gain traction here (see below)
- Long term: We need to carefully consider our options and remain agile in what is a rapidly evolving technical and commercial landscape.

11.1.3. Navigating Those Obstacles

We consider the coming months as presenting a valuable opportunity for the industry to take a step back and consider the learnings from the following anticipated publications/consultation feedback sessions:

- TRANSITION Close Down Report
- FUSION Close Down Report
- Ofgem's Call for Input: Engaging domestic consumers in energy flexibility

We plan to capitalise upon the opportunities that the coming months present to digest these learnings to inform and update our short-, medium- and long-term flexibility business strategies and evaluate the relative merits of the options available.

11.1.4. Likelihood of Large-scale Future Deployment

End-to-end platform

To date our BaU Flexibility Services team, operating discretely from FUSION, has used two platforms, one for procurement (Piclo) and one for dispatch and settlement (Flexible Power).

During ED2 SP Energy Networks will need to utilise the flexibility services we contract to manage network constraints, and to also procure further services in specific areas to support the networks.

To do this we require third party platforms that will allow us to run competitive tenders, schedule services, issue dispatch instructions and settle invoices for services delivered. Licence condition 31E obliges us to procure flexibility services in the most economic way.

One of the learnings from Project FUSION is the feedback that stakeholders had an appetite for a single, highly automated, end-to-end platform.

Currently there is no single end-to-end platform available that has been tested in the UK market.

It is our intention to continue with the status quo BaU arrangement for the short term, but to trial a potential end-to-end platform in parallel, which will provide valuable learning to inform the specification of an enduring solution, with a view to contract by mid-ED2.

Day-ahead trading

Alongside embedding our business-as-usual flexibility processes, we are continuing to investigate new platforms and contractual processes to develop closer-to-real-time markets. In recognition of their associated benefits, as demonstrated in the FUSION project, we are developing our processes and systems to be able to deliver day-ahead trading within the next 24 months.

Coordination with ESO

Following FUSION's trial implementation of Primacy rules, we are continuing to co-ordinate with the Electricity System Operator (ESO) to realise and optimise whole system benefits. ensuring information is shared in real time, and there are clear and mandatory primacy rule obligations, is an important requirement to facilitate near real time markets and will be an integral part of the processes we develop.

Standardisation

We will continue to contribute to industry working groups to implement further standardisation, and this year will co-Chair two of the Open Networks Technical Working Groups.

Baselining

We will seek to collaborate with aggregators to help them to improve the accuracy of their baselining.

11.1.5. Implementation activities and actions

Component	Implementation	Actions required
End-to-end platform	Mid-term: Trial an end-to-end platform. Long-term: Potential for large-scale implementation	**SP Energy Networks –** Trial a potential end-to-end platform and use the learnings for developing an enduring solution **Ofgem** – monitor the development of end-to-end platforms and their benefits, consider what the optimal solution for the UK is. Take into account FUSION's learnings for creating a common digital energy infrastructure (CDEI) and how it should look like.

Day-ahead trading	Mid – term: Deliver day-ahead trading in the next 24 months.	**SP Energy Networks –** Update existing flexibility services agreements (FSA) and services requirements. Ensure that forecasting and planning tools to support day-ahead are in place. **Flexibility Providers/ Aggregators –** Ensure that they have the monitoring and forecasting capabilities to participate in day-ahead trading.
Co-ordination with ESO	Mid and Long term: Learnings and recommendations from the Primacy Rules trial should be taken forward and support the development of additional primacy rules.	**SP Energy Networks -** Implement recommendations from the trialled primacy rule (BM1a). Monitor the need for implementing other primacy rules as they develop. **ENA ON – P -** Continue to develop the rules to incorporate more use cases and evolve the data exchanges to make the existing rules more efficient.
Standardisation in flexibility markets	Mid and Long term: Learnings from USEF's Market Co-ordination comprehensive scope could inform a UK's journey toward a flexibility trading standard.	**SP Energy Networks - Co -** Chair two of the Open Networks Technical Working Groups and provide insights and learnings from FUSION. **Ofgem -** Consider how standardisation in flexibility markets can be achieved. This can involve the creation of platforms, standardisation of communication, **ENA ON – P -** Continue standardisation of products and services to encourage participation of new flexibility, standardisation of processes and communication exchange.
Baselining Improvements	Short- to med- term: Improve baselining accuracy	**Flexibility Providers/ Aggregators -** Aggregators should collaborate closely with the DSO to monitor the quality of their baseline and implement changes to their methodologies if required **SP Energy Networks:** Collaborate closely with aggregators to provide them with feedback and help them improve, understand the baselining impact on flexibility delivery and network impact **ENA ON – P –** Standardise ongoing monitoring of baseline accuracy, standardise the metrics for evaluation of baselining quality (including acceptable ranges) and the reliability of flexibility delivery

		ENA ON-P to consider of Same – Day Adjustment in baselining
Commercial Mechanisms & User experience	Med-to long-term: Use learnings from FUSION to increase participation in flexibility markets and particulate from residential sector	**SP Energy Networks and ENA ON-P -** consider the potential benefits of USEF features and FUSION mechanisms: - Targeted Campaign for residential customers - Automation in trading processes and communication - Discretionary bids, day-ahead trading - Smooth onboarding process of new assets via the Common Reference - Monitor and align with outputs from Ofgem's call for input "Engaging domestic consumers in energy flexibility"
Free bids (discretionary bids)	Learnings from the development and testing of this feature will inform an analogous BaU feature if SPEN decides to take this ahead.	**SP Energy Networks -** consider the payment structure and contractual arrangements which would leverage the mechanism of free bids. **Flexibility Providers/ Aggregators** Consider and develop capabilities required to use the free bids mechanism. For example, short-term monitoring capabilities of assets are required so that aggregators can respond in close-to real time signals and adjust the demand/generation of their assets. In addition, FPs need to be able to identify the free bids, outside the contractual service windows.

11.2. Further Opportunities to Add Value

We recommend hosting an industry workshop to collectively reflect upon how the learnings from the following publications interact and how those learnings can inform our short-, medium- and long-term strategies.

In order to move the USEF concept to a higher TRL, we suggest that trials demonstrating the following USEF capabilities could add value:

- Automated settlement.
- Deployment with a single end-end platform.

We also suggest considering the following opportunities to add value:

Topic	Further work and involved actors
Sub-metering arrangements, #1	ENA ON-P – Further work/project on understanding the impact of sub-metering arrangements in baselining accuracy and settlement costs compared to using MPAN data.
DSO Cost procurement drivers, #2	SP Energy Networks and ENA ON-P: Further work/ trials to explore understand how different measures would impact both the DSO and aggregators and explore the following questions: • How do the risk distribution affect the flexibility cost?

	• How can it be achieved without hampering the entry of flexibility into the market? • How does it affect the decision process of the DSO? • Should reliability and baseline quality be included in the tendering process? How would that affect the aggregator and the DSO? • How would the inclusion of other baseline methodologies, e.g. historical with same-day-adjustment, would affect the DSO?
LV Forecasting and D – programmes, #3	During the FUSION trial, we did not manage to integrate D-programmes into the existing DSO forecasting. A future project could be to integrate a feature such as D-programmes in DSO forecasting and understand how LV forecasting and visibility can improve.
Common Reference in conjuction with primacy rules, #4	During the primacy rules trial we identified some improvement in data exchange between DNOs and the ESO. The common reference could be extended to include this type of information (ESO-DSO Coordination). A potential Project would be to extend the common reference in testing one of the primacy rules that have not been tested yet.

11.3. Peer review by other Licensee

As per the requirement of clause 8.39 of thre NIC Governance Document, this Close Down Report was peer reviewed by another DNO (National Grid Electricity Distribution - NGED). The NGED review concluded that the report is clear and understandable and that it provides sufficient information for a Network Licensee, not closely involved in the Project, to effectively consider whether and how to implement the Project's learning into its business as usual activities.

More detail is available in Appendix 3 – 'Peer Review'.

12. Learning Dissemination

Dissemination Activity	Feedback	Incorporation of feedback
Published reports: • Key learnings reports were uploaded regularly to the Project FUSION website. • Section 13 of this report provides details of the key learnings documents that were published on the FUSION website	None	None
Online video updates • Published on LinkedIn to report on the live trial status and latest interim learnings.  	None	None

Baselining webinar & report • Published on the FUSION website 	1. Consider more refined asset-tailored baselining 2. Consider alternative services that don't require baselining	1. The inclusivity and adaptability of nomination baselines to suit different technologies is addressed in Section 4.1.4 2. Learning 4 in section 4.2 recommends further consideration into how best to split the risk of reliability of delivery (and the accuracy of/ need for baselining) between DSO and aggregators, as a function of the services being considered.
Ofgem Show & Tell webinar (Dec 2022) • Teams webinar with Q&A	1. Clarify the distinctives of USEF. 2. To what extent do SPEN plan to adopt USEF an why/not?	1. The distinctive elements of USEF are articulated in Section 3 of this report. 2. The plans for BaU adoption are are articulated in Section 11 of this report.
ENA event: Oxford Energy Innovation Forum (Sep 2023) • In person presentation with Q&A	1. How did FUSION achieve high residential participation? 2. What are discretionary bids and what is their value? 3. Did we consider the impact of sub-metering on baselining? 4. Does FUSION recommend a user-based system (where the customer manages his load) or a system based approach (via aggregator)?	1. An analysis is provided in sections 2.6.1 (learning 5), 4.2 (learning 5) and 5.2 (objective 2). 2. The report provides the following by way of response i. Description: Section 3.2.3 ii. Evaluation: Sections 4.1.6, 4.4 (learning 4) and 5.2 (objective 2) iii. Recommendation: Section 11.1.5 3. The impact of submetering on baselining is considered in Section 4.1.7 of this report. Recommendations for next steps are provided in Section 11.1.5 4. FUSION did not explore the user-based approach described, and has no view on it. That said our experience of working with aggregators was positive.
Energy Innovation Summit (2022) The FUSION video was • Learnings video was made available on handheld device at the SPEN stand. • FUSION colleagues were available to answer questions.	None	None

13. Key Project Learning Documents

Document Title and Link	Summary
Quantifying Flexibility Report	This report quantifies the flexibility within the study area and brings togeth er the key findings from three sector specific report. The report focuses on industrial, commercial and SME sector, farming sectors and domestic sectors.
USEF Due Diligence Report	This report documents the findings of a due diligence process of the Universal Smart Energy Framework (USEF) against legal, regulatory and market arrangements governing the GB energy sector.
Consultation Document	Informed by the due diligence, this consultation document set out recommendations for implementing USEF in the GB energy system. The consultation informed the FUSION flexibility market trial, where key USEF concepts were implemented in practice to assess their feasibility and effectiveness.
USEF Consultation Report – Full USEF Consultation Report - Executive Summary	This report summarised the outcomes of the consultation process and the next steps for Project FUSION that would be considered for trial implementation.
USEF Associated Changes Report	This report summarises changes that were required to be eimplemented to USEF in order to fit in GB arrangements and FUSION trial. The document was informed by the due diligence and the consultation.
FUSION USEF Implementation Plan	The document presented an implementation plan of USEF which focuses on the development and implementation of USEF elements in the FUSION trial. These elements were divided into 'innovative USEF elements' and 'additional USEF elements' that the Project FUSION partners agreed to include in the trial scope. In addition, the report provided an overview of the USEF processes, information exchange, and IT architecture that SP Energy Networks and flexibility providers would implement for the FUSION trial.
GB Reference Implementation of USEF	Roadmap for the GB energy industry to use learnings and experience gathered in the USEF community and implement innovations that are beneficial to the GB market.
USEF Process Implementation Platform Communication & Procurement Specification	This document set out the roles and functional requirements for the FUSION Flexibiltiy Platform that delivered the USEF trial for FUSION. The document should be read in conjction with the USEF Implemenetation Plan which provides more detailed description of USEF elements.
Specification of communication protocol between market participants	This document sets out the minimum requirements for implementing the USEF Flex Trading Protocol (UFTP). The UFTP formed the basis for the communication protocol that was adopted in the FUSION trial. This report can be used by GB flexibility providers as a guide to the process and technical requirements to participate in the FUSION trial or other trials.
Flexibility Services Aggrement	Flexibiliy Services Contractual arrangements for FUSION trial participants.
Quantification of market participant costs for implementing USEF interface compatibility	This document provided a guide to GB aggregators to identify the potential costs to meet the requirements to participate in the FUSION trial
Expression of Interest (EoI) Response Form	Expression of Interest Response Form for flexibiltiy providers
Trial Learning Report 4 - Final Instalment (April 2023) Interim Trial Learnings Report 3 (Dec 2022)	This suite of 4 documents includes all the detailed análisis of trial learnings, including recommendations and next steps. Report 1 inlcudes

Interim Trial Learnings Report 2 (May 2022) Interim Trial Learnings Report 1 (Oct 2021)	also the detailed description on the detailed steps that Project FUSION followed to get ready for the live trial.
Delivered February 2022, FUSION CBA Report	Updated cost Benefit análisis of FUSION, delivered by Imperial College London
Trial Learnings report: Primacy Rules Implementation (March 2023)	Learnings and recommendations derived from the 'primacy rules' trial in which SP Energy Networks (Project FUSION) and National Grid ESO (NGESO) collaborated between Nov 2022 and Jan 2023. The trial tested primacy rule 1 (Balancing Mechanism vs DNO Active Power flexibility Service.
Development and impact quantification of primacy rules	This report focuses on the interaction between Short Term Operating Reserve (STOR) providers and Active Network Management (ANM) generators in the same area where opposite instructions are issued by the ESO and DNOs. It explores the use case in which the ESO instructs a STOR generating asset to increase MWs, and subsequently the DNO curtails a different generator through ANM, which counteracts the ESO-instructed STOR service.
Yearly progress reports: FUSION Project Progress Report (Year 1) FUSION Project Progress Report (Year 2) FUSION Project Progress Report (Year 3) FUSION Project Progress Report (Year 4)	These annual reports provide a yearly snapshot of progress made on the project during the preceding 12-month period. They include updates on the achievement of key deliverables, budget performance, difficulties encountered, learnings generated, dissemintation activities completed and an assessment of project risks. They are mandated by the NIC Governance Document.
Close Down Report	Close Down Report of Project FUSION as per Ofgem's guidance for NIC projects.

14. Data Access Details

To access and download material generated through the project, please visit the FUSION website using the below link:
https://www.spenergynetworks.co.uk/pages/fusion.aspx#tablist1-tab4

Access to the project data must be requested by contacting SPInnovation@spenergynetworks.com.
Please provide the following information in your request:
• Affiliation, position and contact details of requesting party
• Relevant project and type of data required
• Reasons for requesting this data and evidence that this data will be used in the interest of the UK network electricity customers

Full details on the SPEN data sharing policy is described on the link below:
https://www.spenergynetworks.co.uk/pages/data_sharing_policy.aspx

15. Material Change Information

There were no material changes.

16. Contact Details

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17. Appendix 1 – Glossary

Term	Definition
Aggregator (AGR)	A service provider that contracts, monitors, aggregates, dispatches and remunerates flexible assets at the customer side. (USEF terminology)
Availability Payments	Payments made for being available to deliver the contracted Flexibility Service during a specified time period (described as the 'Service Window').
Common Reference (or congestion point repository)	USEF defines the Common Reference as a repository which contains information about connections and congestions points in the network.
Common Reference Operator (CRO)	In USEF, the CRO is responsible for operating the Common Reference. The CRO's role is to ensure the publication of both the DSO flexibility requirements and the associated flexibility assets in each congested point as well as the standardisation of this publication for all distribution areas.
Congestion Management	The avoidance of the thermal overload of system components by reducing peak loads. The conventional solution to thermal overload is grid reinforcement (e.g., cables, transformers). Congestion management may defer or even avoid the necessity of grid investments.
Constraint Management Service Provider (CMSP)	A provider of constraint management services to a DSO or the TSO. This is a USEF role and is not currently used in GB. This role takes on specific responsibilities in communicating and coordinating flexibility transactions with the ESO and DSO, to ensure effective deployment of flexibility as well as effective management of network constraints. Responsibilities also involve ensuring efficient dispatch of flexibility to maintain the safety and reliability of the networks.
D-programmes	Aggregator forecast of the amount of energy to be consumed or produced at a given congestion point to be shared with DSO in congested distribution network areas.
Delivered Flexibility	The term delivered flexibility is used solely for flexibility that meets the FlexOrders. It is the amount of the ordered power that was delivered during the activation window

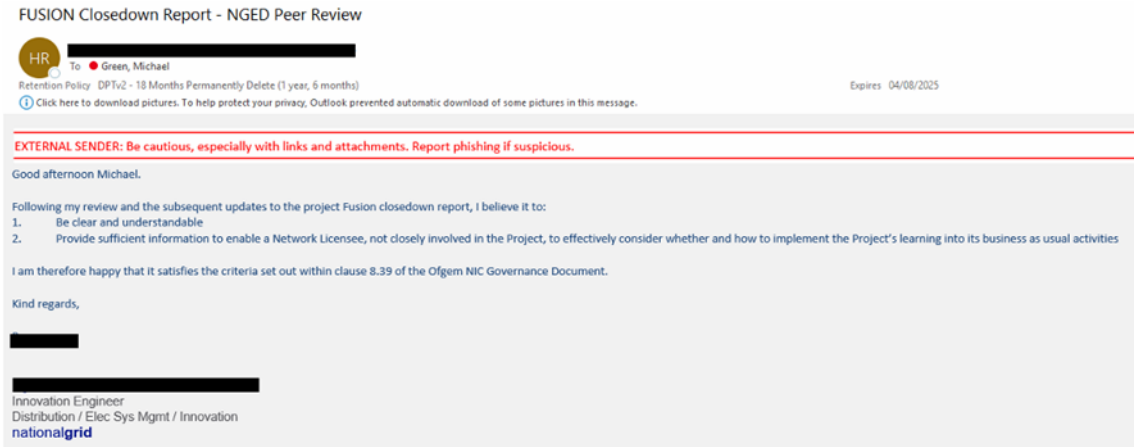
	measured by looking at the change in power from the baseline to the meter readings and capping it at the power output agreed in the FlexOrder
Distribution System Operator (DSO)	As defined in DIRECTIVE 2009/72/EC: A natural or legal entity responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.
Flexibility	Ability of an asset or a site to purposely deviate from a planned or normal generation or consumption pattern.
Market Coordination Mechanism (MCM)	The Market Coordination Mechanism in USEF includes all the steps of the flexibility trading process, from contractual arrangements to the settlement of flexibility. USEF splits the flexibility trading process in five phases and describes the interactions between market participants and information exchange requirements in each phase of the MCM.
Prosumer	This role refers to end-users who only consume energy, end-users who both consume and produce energy, as well as end-users that only generate (including on-site storage). (USEF terminology)
Realised Flexibility	The total change in power from the baseline to the meter readings during the activation window.
Settlement Period	The time unit for which imbalance of the balance responsible parties is calculated. In GB is 30 minutes.
USEF Flexibility Trading Protocol (UFTP)	A protocol that describes the interactions for the exchange of flexibility between aggregators (or other flexibility service providers) and DSO.
Utilisation Payments	Payments made to flexibility service provider for energy delivered as part of a Flexibility Service

18. Appendix 2 – Roles and responsibilities

The table below shows the USEF roles in the FUSION trial and the market party that will perform them.

USEF Role	Inclusion in FUSION trial	Performed by	Comments
Distribution System Operator (DSO)	Yes	SP ENERGY NETWORKS	
Electricity System Operator (ESO)	No	n/a	
Prosumer	Yes	DERs owners contracted by participating Aggregators	
Active Demand Supply (ADS)	Yes	DERs managed by participating Aggregators	
Aggregator	Yes	Flexibility providers: Engie and Orange Power	Selected Through industry engagement and tendering process
Supplier	No	n/a	
Capacity Service Provider (CSP)	No	n/a	The Aggregator can also be active in the capacity market, but the trial will not trial the interactions with this role
Constraint Management Service Provider (CMSP)	Yes	Flexibility providers: Engie and Orange Power	Through industry engagement and tendering process
Balancing Services Provider (BSP)	No	n/a	The Aggregator can also be active in balancing products, but trial 1 will not test interactions with this role
Balance Services Responsible Party (BRP)	No	n/a	The Aggregator can also be active in wholesale trading, but trial 1 will not test interactions with this role
Common Reference Operators (CRO)	Yes	SP ENERGY NETWORKS	
Meter Data Company (MDC)	Yes	SP ENERGY NETWORKS	SP ENERGY NETWORKS will take this role by default
Allocation Responsible Party (ARP)	No	n/a	Wholesale settlement out of scope

19. Appendix 3 – Peer Review



FUSION Closedown Report - NGED Peer Review

HR [redacted]

To Green, Michael

Retention Policy DPTv2 - 18 Months Permanently Delete (1 year, 6 months) Expires 04/08/2025

Click here to download pictures. To help protect your privacy, Outlook prevented automatic download of some pictures in this message.

EXTERNAL SENDER: Be cautious, especially with links and attachments. Report phishing if suspicious.

Good afternoon Michael.

Following my review and the subsequent updates to the project Fusion closedown report, I believe it to:

1. Be clear and understandable
2. Provide sufficient information to enable a Network Licensee, not closely involved in the Project, to effectively consider whether and how to implement the Project's learning into its business as usual activities

I am therefore happy that it satisfies the criteria set out within clause 8.39 of the Ofgem NIC Governance Document.

Kind regards,

[redacted]

[redacted]

Innovation Engineer

Distribution / Elec Sys Mgmt / Innovation

nationalgrid